SEP 5 192

MECHANICAL ENGINEERING

INCLUDING THE ENGINEERING INDEX

OIL—AN URGENT ISSUE

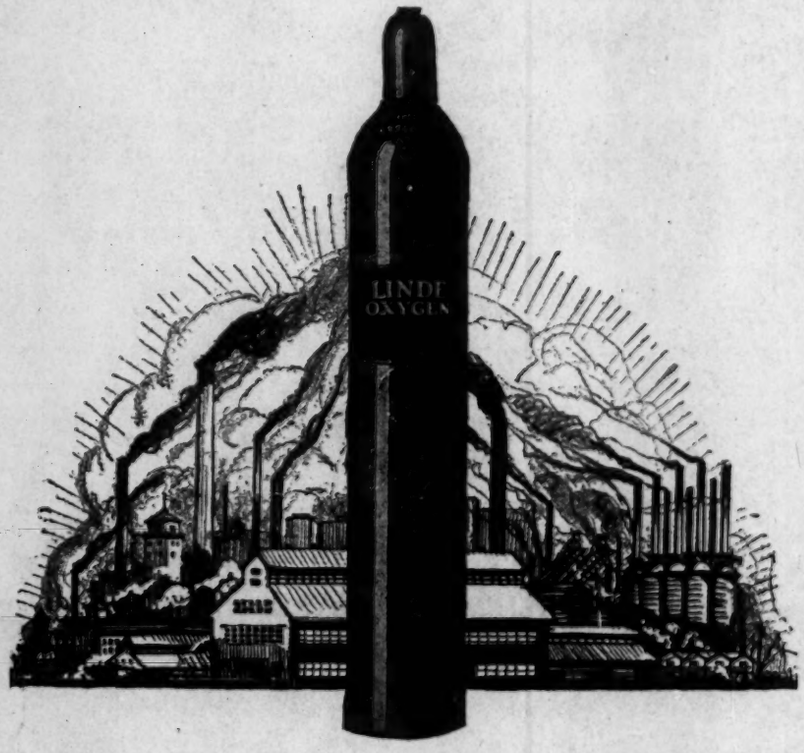
Waste in producing, in transporting, and in using oil should be prevented or curtailed as far as is economically practicable.

Increased concentration of thought and experimentation on the more efficient use of the oil now available, and on the production of commodities of greater efficiency, are economically urgent. DAVID WHITE

in The Oil Supply of the World (*Page 527*)

SEPTEMBER 1922

THE MONTHLY JOURNAL PUBLISHED BY THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS

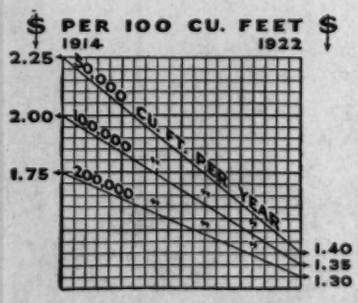


A Policy and Its Results

In 1914 when the oxygen industry was in the early stages of development the LINDE COMPANY adopted as two important features of its sales policy:

First: A definite schedule of prices based on consumption.

Second: A reduction of prices as rapidly as increased volume warranted.



The accompanying chart shows typical prices applying in 1914 as compared with those applying under our new 1922 schedule. This illustrates clearly the benefits to LINDE users of the continued application of these two features to the large increase in production since 1914.

The 1922 prices shown for the respective consumptions are the average for the entire chain of 30 plants and 50 warehouses through which LINDE OXYGEN is distributed today. Slightly lower prices prevail at the plants in districts of heavy oxygen demand. Higher prices prevail where shipments are made from convenient service warehouses, or where undeveloped consumption does not permit large scale plant production and distribution.

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2281-22

Mechanical Engineering

The Monthly Journal Published by

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TABLE OF CONTENTS

The Oil Supply of the World, David White ... 567
Mechanical Refrigeration of Railroad Cars, W. M. Baxter ... 570
The Helicopter and the Variable Pitch Propeller ... 575
Acid-Resisting Metals and Alloys, G. A. Drysdale ... 593
Tests on Welded Cylinders, E. A. Fessenden and L. J. Bradford ... 581
Steam Utilization in a Modern Newsprint Mill, S. W. Slater and J. E. A. Warner ... 587
Progress in Synthetic-Gasoline Production, Roy Cross ... 593
Survey of Engineering Progress ... 596
Thermo-Calorimetric Heat Value—Short Abstracts of the Month.
Engineering Research ... 607
Work of the A.S.M.E. Boiler Code Committee ... 609
Correspondence ... 611
Editorials ... 614
Jurisdictional Board Asks Coöperation of Engineers—German Standards—Beneficial Effect of Prizes.
Alfred D. Flinn Reports Nationwide Interest in Research ... 616
St. Louis Central Station to Use Pulverized Fuel ... 616
DeLamater-Ericsson Collection to be Nucleus for National Museum of Engineering ... 616
Remarkable Steam Locomotive Sets New Standard ... 617
Alexander Graham Bell, Father of the 'Phone, Dies ... 618
The Treasure House of Aeroplane Design ... 619
Engineering and Industrial Standardization ... 620
Book Notes ... 621
Engineering Index ... 622

Advertising Section
Display Advertisements ... 631-EI
Consulting Engineers ... 90
Classified Advertisements ... 97
Classified List of Mechanical Equipment ... 98
Alphabetical List of Advertisers ... 116

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Contributors and Contributions

The Oil Supply of the World

DAVID WHITE

The question of where the United States will find oil to meet its demands after the oil fields of the country have passed their peak of production has been urged upon public attention for several years by David White, whose paper on the Oil Supply of the World appears in this issue. Mr. White was graduated from Cornell University in 1886, and since that time has been engaged in the U. S. Geological Survey. His first studies were of fossil plants. This led him into the study of coal and its origin, and this in turn brought him to the study of oil and the principles controlling the movement and distribution of oil in the geologic formations of the earth. These studies resulted in the publication by Mr. White in 1915 of the Law of Carbonization, which is now recognized by nearly all geologists.

In 1920 Mr. White formulated and published the first compilation of estimates of the oil resources of the world. The present paper slightly revises and extends these estimates and includes a discussion of the new estimates of the oil resources of the U. S.

Steam Utilization in a Modern Newsprint Mill

This paper, which reports the results of tests made to determine the factors influencing steam consumption in the drying of newsprint paper, was written by S. W. Slater and J. E. A. Warner. Mr. Slater, after leaving Stevens Institute of Technology, was in the employ of Walter Kidde and Co. on power-plant design and construction. From 1910 to 1916 he was associated with the Brooklyn Union Gas Co. and since then has been with the St. Maurice Paper Co., Ltd., at Cape Madeleine, Quebec.

Mr. Warner, after completing his course at McGill University, was in the gas-engine department of the Canadian Fairbanks-Morse Co. and with the Dominion Water Power Branch on the investigation of hydro-electric improvements. During the war he served overseas and since 1919 has been associated with the St. Maurice Paper Co., Ltd.

Tests on Welded Cylinders

A comparison of methods for constructing cylinders for handling anhydrous ammonia is contributed by E. A. Fessenden and L. J. Bradford. Professor Fessenden resigned his position as head of the Department of Mechanical Engineering at Pennsylvania State College this spring to accept a similar position at the Rensselaer Polytechnic Institute. He received his degree of Bachelor of Science in Mechanical Engineering from the University of Missouri in 1906, and his degree of Mechanical Engineer two years later. He has had a successful teaching career and has done much research and experimental work, particularly at the University of Missouri Engineering Experiment Station. He is a member of the Society for the Promotion of Engineering Education and has been a frequent contributor to engineering journals.

L. J. Bradford received his B.S. from Swarthmore in 1911 and his M.E. from Cornell in 1916. He was an instructor at Swarthmore College for a year and at Sibley College from 1912–1918. For the last year of that period he was Acting Assistant Professor of Machine Design, and since 1919 has been Assistant Professor in charge of Machine Design at Pennsylvania State College. He, too, has been a contributor to the various engineering journals.

Acid-Resisting Metals and Alloys

George A. Drysdale, whose paper on Acid-Resisting Metals and Alloys appears in this issue, was educated at King's College, Nova Scotia, and McGill University, where he received his B. A. Sc. in 1898 and his M. Sc. in 1911. After his graduation he held positions with the Howard & Bullough American Machine Co., Pawtucket, R. I., the Stover Manufacturing Co., Freeport, Ill., the Solvay Process Co., Detroit, Mich., and the International Harvester Co. at Hamilton, Ontario. For the past eleven years he has been with the Midwest Engine Co. (formerly the Atlas Engine Works) at Indianapolis, Ind., where he installed their laboratories, and he is now metallurgical engineer at both their Indianapolis and Anderson plants.

Mechanical Refrigeration of Railway Cars

William M. Baxter contributes a paper on the Mechanical Refrigeration of Railway Cars. Mr. Baxter is the president of the Baxter-Stewart Refrigerator Transport Co., and vice-president of the Ideal Truck Equipment Co., both of Chicago.

Progress in Synthetic-Gasoline Production

Dr. Roy Cross is a graduate of the University of Kansas in 1905, and of the University Medical College in 1908. Upon graduation he started the Kansas City Testing Laboratory, doing a general consulting practice in chemical engineering and material inspection. He later took post-graduate work at the University of Tulane. He is now general manager of the Laboratory and in conjunction with his brother has spent fourteen years working in the chemistry and engineering of petroleum.

The Helicopter

Toys have their place in scientific development. The top has been put to work in the gyroscopic compass and now the helicopter, which has amused several generations of small boys, is seriously considered as a flying machine. An analysis of the problems involved and some information about progress appears in this issue.

Coming A.S.M.E. Events

Regional Meeting at Springfield, Mass., September 25-27

Trip to Aberdeen Proving Ground, October 6

Management Week, October, 16-21

The A.S.M.E. NEWS will carry complete advance information about all of them.

MECHANICAL ENGINEERING

Volume 44 September, 1922 No. 9

The Oil Supply of the World

Estimates of the Oil Resources of the Various Regions of the Earth—The Economic Future as to Oil in the United States—Measures Necessary to be Taken in Order to Increase and Conserve the Domestic Supply

By DAVID WHITE,[1] WASHINGTON, D. C.

THE question is asked, Why is the United States, whose market is now suffering from a slight excess of oil supply, especially concerned about how much oil there is in our own country and the world? Are we trying to corner the world's oil? Do we fear harmful competition from countries more richly supplied? Are we running short of oil, or is there oil famine in other parts of the world that threatens to draw too heavily on our supplies in competition with our own people, with consequent raise of oil prices to levels harmful to the consumers of this country? The concern of the public in the economic problem of oil supplies arises from the following outstanding features of the situation, which give the question an incisive significance to every American user of oil.

To date the United States has furnished nearly two-thirds of all the oil yet taken from the ground in the world—5.5 billions of barrels out of a total of 8.5 billions. Our American fields are now pouring out 62 per cent of the world's annual supply, while our country is using over 75 per cent of that total supply. In other words, the United States requires over 115 million barrels more than it produces; for, whereas our output now approximates 470 millions yearly, our requirements, even during the business stagnation of 1921, called for 525 millions. Our autovehicle program, already passing 10 million cars, is still growing; our merchant ships must burn oil to compete with those of other nations; there are bound to be more tractors and trucks, pumps, small machinery and miscellaneous equipment; and air service is destined to become an everyday necessity. Everywhere, except perhaps in the Navy, the demand for even more oil is in evident prospect. Nothing can check the increase more than momentarily, except high prices due to scarcity of oil or high costs of production or importation—that is, the greater expense of obtaining the oil.

Where will the oil to satisfy these requirements come from year after year, and how long can we keep up the pace? These are plain, common-sense business questions, predicted on our present oil requirements as an established fact and on the suggested possibility that our prodigal spending of our petroleum heritage may cause its too rapid depletion if not its early exhaustion in the midst of our spendthrift career, and at some untoward moment send us as beggars to foreign countries for the precious fluid necessary not only to satisfy our extravagant habits, but even to sustain our industrial prosperity, our standards of living, and our civilization.

Obviously there is only one first thing to be done, and that is for the nation to proceed in the nation's business just as the business man proceeds under similar conditions in his private business, namely, to take account of stock, to find out how much oil there is left in the United States and then to learn as nearly as possible how much oil there is in the rest of the world and where the principal deposits or reserves are located, due consideration being given to probable availability and conditions of production of these reserves.

No apology, therefore, is needed for the searching appraisal and careful estimate recently made of the oil reserves remaining in the ground recoverable by present methods in the United States, nor for its publication for the information and advice of the industry and the country at large. The justification of the formulation of estimates of the oil reserves in other countries, based upon long and painstaking studies of the available data relating to the oil reserves and relative oil possibilities of those other regions of the world, is evident. Such information is indispensably requisite for understanding the present economic situation.

Known Oil Resources of the World

The oil reserves to be found in the regions of the earth where oil has already been proved to exist in commercial amounts were in 1920 estimated by Eugene Stebinger and the author at 43 billions of barrels, as listed in Table 1. This calculation is based upon a review of the available data as to the regional geology the structure, the character and composition, thickness, relations, and alteration of the sedimentary deposits of the different basins, the information as to local and minor folding, and as to surface indications of oil, and finally the records as to developmental tests or actual production. The consideration of the geology of other regions in which oil has not yet been proved to be present in commercial amounts led to the formulation of an additional estimate of 17 million barrels for these regions, placing the total estimate for the world's oil reserves in the ground and recoverable by present methods at 60 billions of barrels. As stated at time of publication, these estimates are necessarily highly speculative and, in spite of the care and study given to their preparation, are subject to great range of error, especially with reference to non-producing countries and to those concerning which the geologic information is meager. They are avowedly conservative. From data subsequently reviewed and on consideration of further information in hand, the author is disposed to regard the estimates for eastern Siberia, Sakhalin, India, Assyria, and Arabia as much too low, with the probability that the oil content of South America will exceed 13 billions of barrels. He accordingly believes that an estimate of 70 billion barrels for the world's total resources is conservative.

TABLE 1 OIL RESOURCES OF REGIONS OF THE WORLD KNOWN TO CONTAIN COMMERCIAL DEPOSITS, AS ESTIMATED BY EUGENE STEBINGER AND DAVID WHITE

Country or region	Millions of barrels
United States and Alaska	7,000
Canada	995
Mexico	4,525
Northern South America, including Peru	5,730
Southern South America, including Bolivia	3,550
Algeria and Egypt	925
Persia and Mesopotamia	5,820
S. E. Russia, S. W. Siberia and the region of the Caucasus	5,830
Roumania, Galicia and western Europe	1,135
Northern Russia and Sakhalin	925
Japan and Formosa	1,235
China	1,375
India	995
East Indies	3,015
Total	43,055

The most important oil regions outside of the United States are believed to be located in Mexico, Venezuela, Colombia, Bolivia, Argentina, Russia, Mesopotamia (together with western Persia), Assyria and Arabia, the East Indies, China and Eastern Siberia (including northern Sakhalin), the Japanese Empire, India, and probably northern Africa. A forecast as to the proportions of light and heavy oils in these great regions would be extra hazardous, but a review of the results of exploration, combined with the consideration of the regional geology, the character of the formations and the stages of alteration, tends to confirm the very natural assumption that the

[1] Chief Geologist, U. S. Geological Survey.

Presented at the Regional Meeting of the Local Sections of The American Society of Mechanical Engineers, Kansas City, Mo., March 6 and 7, 1922. Slightly abridged.

production of all of these regions will include moderately light, and in some regions very light, oils as well as, in nearly all cases, fuel oils.

A review of the map compiled by Mr. Stebinger and used in numerous discussions, including the author's paper in the Annals of the American Academy of Political and Social Science for May, 1920, indicates a concentration of the world's oil resources in the northern subtemperate and tropical regions of the earth. Many of the great reserves are distributed along the north Pacific border, the region of the Indian Ocean, and the western Atlantic. Most of them are easily tributary to the principal routes of maritime world trade. It is likely that further investigation will show considerable reserves not only in North Africa, but along the west African coast and in Brazil—in other words, on the borders of the south Atlantic.

Concerning the restrictions by which the nationals of the United States are excluded from free participation in the development of the oil deposits of a large part of the world, and in the Eastern Hemisphere especially, to which the author has given some attention, authentic information will be found in two statements prepared by the Department of State.[1] Most American readers are aware of the efforts of our Government to secure entry for American oil companies in Mesopotamia and again in Djambi, which represents the Dutch East Indies. A satisfactory compilation of concessionary as well as political control of the oil resources outside of North America is at present nearly impossible, but it appears practically certain that two-thirds of the world's oil reserves outside of the United States are not open to development by American companies. In some countries the "open door" is not so open as it appears to be. Some of these reserves may in time of peace be available, if needed, to our citizens at a price, but priority of right, if not permanent reservation, will be given to the navies and militaries of the different countries. Undoubtedly whenever our citizens become dependent for oil on foreign reserves in the hands of rival nationals, they will restore with ample interest all the profits enjoyed through many years by the American exporter. Any protection that we may then need should be assured in advance.

Oil Resources of the United States That Are Recoverable by Present Methods of Exploitation

Having considered the wealth of oil in foreign countries which, according to the very conservative calculations given above, is sufficient to meet the present rate of consumption requirements of the aggregate countries outside of the United States for 215 years, we come to the important question as to the sufficiency of the oil deposits of our own country to meet the whole or a considerable part of our own requirements for the future. In other words, what is the economic future as to oil in the United States? Are our supplies ample and shall we be independent, continuing our role as the world's great producer and distributor of petroleum and its products, or are our reserves so rapidly becoming exhausted that we are in the way to become a mendicant for oil among the nations which we have served with such prodigal generosity?

To answer this question, an appraisal of the domestic oil resources in the ground recoverable by present methods of exploitation has just been completed. Taking advantage of the great expansion of oil-field exploration in the United States in the last few years, the results of widespread wildcatting in regions of merely possible as well as probable territory, the proving of entire oil fields as well as pools, the training of hundreds of geologists and engineers specialized in the problems of the geologic occurrence of petroleum, and desiring to apply the best methods as well as the experience developed through oil-field examination and estimation in appraisal or depletion, in accordance with the requirements of existing tax laws, the United States Geological Survey, a year ago, invited the American Association of Petroleum Geologists to appoint from its membership representatives to serve with the oil geologists of the Survey in a joint committee for the estimation of the oil resources of the United States. With the joint committee thus promptly formed, there worked in heartiest coöperation, through sub-committees covering different areas or states, or in direct collaboration, a large number of state geologists, consulting specialists and company geologists especially familiar with the stratigraphy, structure, and mode of occurrence of oil in the different fields. After nine months of compilation, study and discussion, the estimates were reviewed and revised in joint conference, and in January of this year were made public by the Director of the Geological Survey as given in Table 2.

TABLE 2 ESTIMATED OIL RESERVES OF THE UNITED STATES BY STATES OR REGIONS

	Millions of Barrels
New York	100
Pennsylvania	260
West Virginia	200
Ohio	190
Indiana and Michigan	70
Illinois	440
Kentucky, Tennessee, northern Alabama, and northeastern Mississippi	175
Missouri, Iowa, North Dakota, Wisconsin, and Minnesota	40
Kansas	425
Oklahoma	1,340
Northern Louisiana and Arkansas	525
Texas, except Gulf coast	670
Gulf coast, Texas and Louisiana	2,100
Colorado, New Mexico and Arizona	50
Wyoming	525
Montana, Nebraska and South Dakota	100
Utah, Nevada, Oregon, Washington, and Idaho	80
California	1,850
Eastern Gulf Coastal Plain and Atlantic Coast States	10
Total	9,150

These estimates are, naturally, most accurate in those parts relating to proved territory, for which data invaluable for such calculations are now available. In that part relating to probable territory they represent the balanced judgment of a group of chosen specialists including geologists particularly familiar with the regions and their history. The greatest errors may fall in those portions of the total which relate to merely "possible" territory, especially in regions and states in which oil has never yet been proved to be present in commercial amounts. As stated by the author in a discussion of the subject at the New York meeting of the American Institute of Mining and Metallurgical Engineers, in February, the errors of excess in the estimates for disappointing regions are likely, on the whole, to be balanced by the deficiencies in others.

It may be of interest to engineers, who represent the great oil-consuming industries, to note that of the 9 billion barrels which, as of March 15, 1922, should remain in the ground recoverable by present methods, rather more than 4 billion barrels belong to the heavy group containing the fuel oils. Of the class containing the lighter oils about 725 million barrels are believed to remain in the Appalachian states, and 40 million barrels in the Lima-Indiana region. The fuel oils are largely to be found in the Pacific Coast, the Rocky Mountain and the Gulf states.

Economic Situation of Oil as It Affects the United States

In the United States we have at the present moment produced a total of $5\frac{1}{2}$ billion barrels of oil. We have therefore used up more than one-third of our estimated original heritage of oil. In 1921, a year of stagnation of American oil production, we drew out nearly 470 million—practically half a billion—barrels of oil from our reserves, which are now calculated at 9 billion barrels. Contrasted with our more than 5 per cent rate of annual depletion, the rest of the world withdrew in 1921 not much over 280 million from its store of over 60 billion barrels, or less than half of one per cent of its reserves recoverable by present methods. In other words, the reserves of the rest of the world would stand the present rate of drain for over two centuries. From the standpoint of world distribution of oil and the relations of our reserves to those of the rest of the world, an error of 2 or 3 billion barrels—4 to 6 years' supply—in the committee's estimates of the oil reserves of the United States is comparatively insignificant.

The coöperative committee expressly affirms—and it is well known in the profession—that not all the oil pools in the United States will have been discovered a generation hence. On the other hand, the committee takes great care to point out that while our reserves would not meet our present rate of consumption demands for 20 years, if they could be taken out of the ground fast and cheaply enough to supply our market (a conditioning clause that has gen-

[1] Restrictions on American Petroleum Prospectors in Certain Foreign Countries. Message from the President of the United States, May 17, 1920. Senate Document 272, 66th Congress, 2d session.

Restrictions on American Petroleum Prospectors in Certain Foreign Countries. Message from the President of the United States, May 16, 1921. Senate Document 11, 67th Congress, 1st session.

Oil Prospecting in Foreign Countries. Message from the President of the United States, June 13, 1921. Senate Document 39, 67th Congress, 1st session.

erally been lost sight of by the press and the public), this country will be producing oil for as long as 75 years to come.

Since oil cannot so rapidly be located and taken from the ground, it follows with certainty that, according to the laws of oil production, the annual oil output of the United States must at an early date pass its peak and enter upon a long-drawn-out period of general though fluctuating decline to ultimate exhaustion, except so far as fields in great numbers may be rejuvenated by better methods of mining. Opinions differ as to how soon the production peak will be passed; but most geologists believe that within a few years, perhaps less than five, we shall in the normal course enter on a period of waning fields in increasing number, with discoveries more infrequent and in general more costly. The date of passage of the peak depends largely on the demand for oil and the reflected oil prices. If supplies from foreign sources continue adequate and cheap for a long time the passage of the peak may be insensible though early; but should they be seriously curtailed or largely cut off for a considerable period in the near future, we probably shall then see our operators driven by high prices to the greatest maximum, in which an overoptimistic industry will eventually have found it has passed the peak.

A large portion of the public does not yet fully recognize that the United States is already dependent upon foreign oil to meet its still growing requirements. Our oil importations which were 18 million barrels in 1913, grew to 38 million in 1918, 53 million in 1919, 106 million in 1920, and 125 million in 1921. A small part only (9 million barrels) of this amount is offset by exportation of crude petroleum from the United States. In short, in a period of industrial depression we have imported one-fourth as much as we produced. Nearly all of this oil comes from Mexico, and that is why Americans are so profoundly interested in Mexican oil.

The present production in Mexico, amounting to about 195 million barrels in 1921, is mostly drawn from a relatively small number of wells located along a single axis of folding in which a thick limestone, the Tamosopo, is caverned by solution and, in the structurally high points, gorged with gas and oil under most tremendous pressure of salt water. No wells of such enormous production are known in any other part of the world. It is common knowledge that most of these wells have gone or are now going to salt water, and on the basis of this fact as differentially interpreted in the light of other geologic conditions in the field, it is believed by many oil geologists, including some of high repute, that the greater part of Mexico's present phenomenal production is on the verge of approximate extinction. It is practically certain that, while some new discoveries of Tamosopo oil may come to the aid of the rapidly failing pools, sooner or later the production of oil from the world-record-breaking Tamosopo limestone gushers will wane, and the remaining portion of Mexico's 4 to 5 billion barrels of oil reserves, as estimated, must be won by the sweat of the oil operator's brow from wells of the ordinary type. The magnitude of the task of developing enough oil fields of the "common or garden variety" in Mexico to take over the load of an annual production of 195 million barrels which was produced from less than 300 wells in 1921, may be inferred from the fact that in 1908, when for the first time the production of oil in the United States amounted to so much as 175 million barrels, over 140,000 wells contributed to the output. This number is, of course, subject to sweeping and radical discount for rapidity of development and freshness of production. It would take over 10 Haynesvilles or a group of 4 Mexias or 14 Salt Creeks, all running full blast, simultaneously, and all continuously maintaining their January rates of production, which, of course, is impossible. It is difficult to estimate the oil price stimulus necessary to develop a production of 200 million barrels of oil in Mexico from wells of the ordinary type under existing transportation, climatic, and industrial conditions within five years. The prices requisite would certainly be most encouraging for the production of oil from shale in this country.

The collapse, or better, the great slump, in Mexican production, which seems sooner or later inevitable, can hardly fail to react on our own oil-field production, probably driving it to the limit; and it is likely that in the early period of this strain the annual output of petroleum in the United States will pass its peak. Beyond this point our need for more foreign oil is likely to spring up from our decreasing domestic production more than from further growth of our consumption requirements. In this period relief must come from other foreign oil fields and from the production, by distillation, of shale oil, on whose adequacy and on whose yet undetermined cost we may be obliged to rely for protection against transoceanic importations at transoceanic prices beyond our control. Too great an advance in price will, of course, check our use of oil and bring it within the bounds of practicably available supplies from all sources, at prices then viewed as practicable. The oil we cannot afford to buy we will do without.

The extent to which failure of Mexican production may be disastrous to this country depends on the completeness of the slump. It depends also, especially in the early stages, on the extent to which the American oil companies have developed or can rapidly develop considerable available production in other foreign regions on the one hand, and, on the other hand, on the extent to which, as the results of scientific research and energetic commercial application, better methods of oil mining are developed and proportions of the oil not recoverable by present methods of extraction are then taken for the ground. As is well known, in most fields and sands the larger portion of the oil remains locked up in the pores of the reservoir sands, even when the fields are "played out" and abandoned. It is believed by engineers who have given most study and experimentation to the subject that an additional recovery of 40 to 80 per cent over that obtained by present methods will ultimately be possible in many of the fields.

ECONOMIC DEDUCTIONS

Around the constructive economic deductions to be drawn from a review even so superficial and elementary as this summary of the high points of the situation as to oil resources, it is to be seen that—

1 The need of foreign oil reserves available for continued use in the United States is obvious.

2 Waste in producing, in transporting, and in using oil should be prevented or curtailed as far as is economically practicable.

3 Increased concentration of thought and experimentation on the more efficient use of the oil now available and on the production of commodities of greater efficiency are economically urgent. On every occasion consideration should be given to the general abandonment of oil to generate steam, in favor of the three-times-as-efficient Diesel motor or some other still more effective substitute.

4 More intense and more widespread researches in the production of liquid hydrocarbons through processes—so-called low-temperature carbonization—aimed at the more efficient use and the wider adaption of our bituminous and lower-rank coals are important.

5 The development on a commercial scale of an oil-shale industry deserves earnest and wise consideration. Naturally there will be waste and loss of this shale through mining first the richest beds, just as takes place in our coal fields. As has been pointed out by Requa and others, the production of oil from oil shales is a matter of mining and retorting ton by ton and predicates the gradual building up of an industry which, to replace one-third of our present petroleum output, would require men, cities, mining plants, machinery, transportation, water, etc., roughly equal to one-third of our bituminous-coal-mining industry. It is a gigantic task requiring years and enormous capital. Above all it requires planning through research, through experimentation, and through patient trial on a commercial scale, with the closest attention by engineers of all kinds to costs as well as products, with the object of placing the industry on a successful basis as a going concern as soon as prices of crude petroleum and conditions as to prospective supplies permit. Studies should be made to show what prices for crudes of different grades will justify the systematic development, in different regions, of oil-shale production. Shale oil, by which is meant artificial petroleum obtained by distillation of oil shale, may be looked forward to as a stabilizer of domestic prices as well as an economic backstop in oil. Eventually, and especially as foreign supplies available to the United States becomes scarcer or too costly, it should guarantee our ultimate independence in oil, and, to this extent, our industrial and social prosperity as well.

6 The recovery of a much larger portion of the oil in the reservoir rocks than is obtained by present methods is an imperative necessity, demanding the faithful, the intelligent, and the immediate consideration of the states and of the Government, as well as of the oil industry.

Mechanical Refrigeration of Railroad Cars

The Technical, Economic and Operating Aspects of Various Attempts to Employ Mechanical Refrigeration in Railroad Refrigerator Cars, Together with Details of a Proposed Dense-Air System for That Purpose

By W. M. BAXTER,[1] CHICAGO, ILL.

THE subject of mechanical refrigeration as applied to railroad equipment is fraught with tremendous difficulties. First, the physical achievement of a successful mechanical process which will meet the multifarious demands of modern railroad transportation has not yet become a fact. Second, the economics of the problem are such as to lead the author to believe that it will be some time before a practical refrigerating machine can be applied to individual refrigerator cars. Third, from a railroad

FIG. 1 ARRANGEMENT OF MACHINERY OF ABSORPTION-REFRIGERATING SYSTEM AT END OF CAR

operating viewpoint any mechanically refrigerated railroad equipment must be held in specified traffic. This is a serious drawback because of the lack of universality of its use, and especially in its acceptance in interchange.

Again, being mechanical, such equipment must have the attention of attendants who must be specifically and practically trained in its maintenance and operation, and even with the most practical achievements along these lines it would be a long time before such a piece of railroad equipment would be heralded by the American railroads.

REFRIGERATING MACHINES

Refrigerating machines, or heat pumps, are machines which will carry heat from a cold to a hotter body. (This statement is not at variance with our knowledge that heat does not flow of itself from a cold body to a hotter body.) This, as the second law of thermodynamics asserts, cannot be done by a self-acting process, but it can be achieved by the expenditure of mechanical work. Any heat engine will serve as a heat pump or refrigerating machine if it is forced to operate in such a way as to trace its indicator diagram backward so that the area of the diagram represents work *spent on*, instead of *done by*, the working substance. Heat is then taken in from the cold body and is rejected to the hot body.

The standard systems of mechanical refrigeration are:

1 *The Dense-Air System*, so called because the air which is the refrigerating system is never allowed to fall to atmospheric pressure. This is done in order to reduce the size of the cylinders and pipes through which a given weight of air may be circulated. This process does not depend upon the liquefaction of the air, as it is not liquefied but simply compressed and expanded adiabatically.

2 *The Compression System*, using ammonia, carbon dioxide, sulphur dioxide, ethyl chloride, methyl chloride, etc., so called to distinguish it from the third system because a compressor is used to raise the pressure of the vapor and deliver it to the condenser and there liquefy it, after removing it from the evaporator or expander.

3 *The Absorption System*, using ammonia and so designated because a weak water solution removes the vapor from the expander or evaporator by absorption. The richer aqua ammonia so formed is pumped into a high-pressure chamber

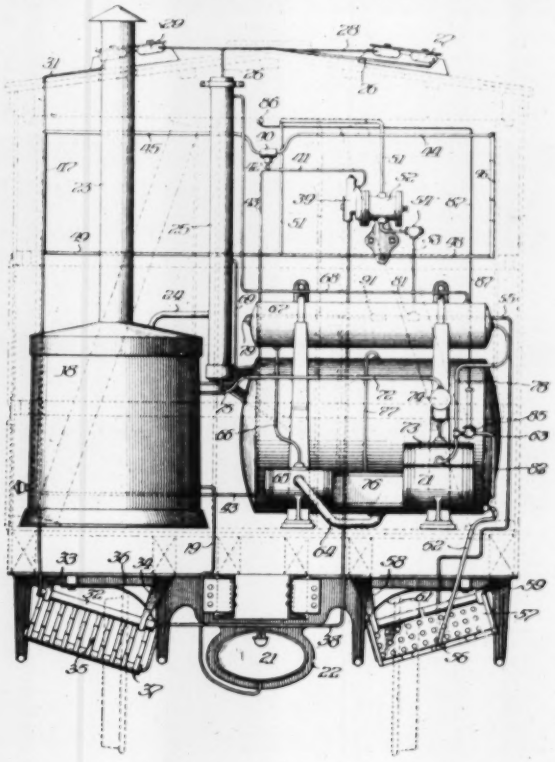

FIG. 2 LATER MODIFICATIONS OF CAR-REFRIGERATING SYSTEM SHOWN IN FIG. 1

(called a generator) in communication with the condenser where the ammonia is discharged from the liquid solution, or rich liquor as it is called, to the condenser by heating the generator, to which the solution is delivered by the only moving part in the process, namely, a slow-moving pump.

The coefficient of performance of refrigerating machines is expressed by the ratio:

$$\frac{\text{Heat extracted from the cold body}}{\text{Work expended}}$$

This ratio may be employed in estimating the merits of a refrigerat-

[1] President, Baxter-Stewart Refrigerator Transport Co.; Vice-President, Ideal Truck Equipment Co.

Abridgment of paper presented at a joint meeting of the Metropolitan Section of the A.S.M.E., and the American Society of Refrigerating Engineers, New York, May 16, 1922. All papers are subject to revision.

ing machine from the thermodynamic point of view. When the limits of temperature T_1 and T_2 are assigned, it is very easy to show that no refrigerating machine can have a higher coefficient of performance than one which is reversible according to the Carnot cycle; for let a refrigerating machine A be driven by another, B, which is reversible and is used as a heat engine in driving A, then, if A had a higher coefficient of performance than B, it would take from the cold body more heat than B (working reversed) rejects to the cold body, and hence the double machine, also purely self-acting, would go on extracting heat from the cold body in violation of the second law. Reversability, then, is the test of perfection in a refrigerating machine, just as it is in a heat engine.

When a reversible refrigerating machine takes in all its heat, namely, Q_c at T_2, and rejects all, namely Q_a at T_1, then, representing the heat equivalent of the work done by $W = Q_a - Q_c$, the coefficient of performance is as already defined:

$$\frac{Q_c}{W} = \frac{Q_c}{Q_a - Q_c} = \frac{T_2}{T_1 - T_2}$$

hence—and the inference is highly important in practice—the smaller the range of temperature, the better the performance. To cool a large mass of any substance a few degrees will require a much smaller expenditure of energy than to cool, say, one-fifth of the mass through five times as many degrees, although the amount of heat extracted is the same in both cases. If it is desired to cool a large quantity of water or air, for example, it is better to do it by the direct action of a refrigerating machine working through the desired range of temperature than to cool a portion through a wider range and then let it mix with the rest. This is only another instance of a general principle that any mixture or contact of substances at different temperatures is thermodynamically wasteful, because the interchange of heat between them is irreversible.

The foregoing explains why it is mechanically more efficient to produce refrigeration on a large-quantity basis than on a small. In consequence, the amount of energy and machinery in proportion to the refrigerating effect had from a small machine on a refrigerating car is thermally out of proportion to the work done.

European Attempts at the Mechanical Refrigeration of Railroad Cars

The year 1912 marks approximately the beginning of serious attempts at mechanical refrigeration of railroad cars. The first effort that achieved any degree of success was that attempted by the chief of motive power and rolling stock of the Moscow-Kazan Railroad of Russia. Here a semi-absorption process was employed, consisting of refrigerating or expander coils located in the roof of the car and a connection on the outside leading from a drum of anhydrous ammonia, with a suitable expansion valve interposed. The other end of the refrigerating coil was conducted to a crude absorber located underneath the car. This absorber was in reality nothing more than a water tank having an aspirator tube placed therein. To start the process in operation it was only necessary to open the expansion valve and expand the gas in the refrigerating coil; the affinity of the water for the gas in the absorber maintained the back pressure and created the low-pressure side of the machine. It was the intention of the railroad to take the aqua ammonia thus formed in the absorber to a stationary regenerating plant and there distill off and reliquefy the anhydrous ammonia and charge it into suitable receptacles or drums which would be kept on hand and reapplied to equipment passing these points, which latter would virtually perform the same function as re-icing stations. This process failed because it was considerably cheaper to use natural ice for cooling purposes.

While attached to the American Army of Occupation as a major of engineers, the author was on one occasion sent to Poland where he saw in Warsaw an interesting car built in 1912 at Cologne, Germany, for the Russian Government Railways from the designs of M. Humboldt. In the central compartment of this car was a 10-hp. oil engine which drove an ammonia compressor of 4 tons refrigerating capacity. The condensing coils were placed under a sunshade roof on top of the car. No water was used for condensation, the day temperature of the atmosphere being depended upon to wipe off the heat of compression and thus liquefy the ammonia. The liquefied ammonia was passed to various expansion valves, one being located in each of the four refrigerating rooms into which the car was divided—two at each end of the engine compartment. By manually controlling these expansion valves different temperatures could be maintained in each of the various rooms if desired. According to a German railroad official in Warsaw, the cost of operating this car was about 80 per cent more than it would have been had natural ice been employed.

At Mayence on the Rhine, the headquarters of the French Army of Occupation, the author observed a rather new departure in car refrigeration, consisting of three insulated cars placed ahead of a central car provided with a refrigerating plant which was followed by two insulated cars. These cars were built and tried out in 1913. The traffic handled was butter and the service was from Kurgan on the Siberian border to Riga on the Baltic, a distance of about 1500 miles. The temperature maintained in the cars was about 35 deg. fahr. Brine was pumped through piping and coils from the central plant which consisted of a complete refrigerating unit designed by the Linde Company, of Wiesbaden,

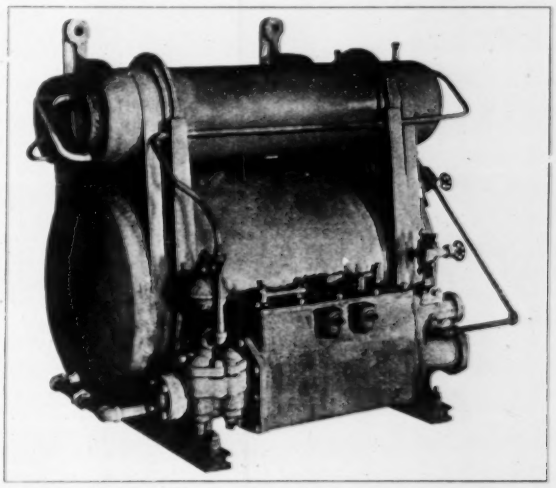

FIG. 3 SECONDARY ABSORBER AND TEMPERATURE EXCHANGER OF FIG. 2

Germany, one end of the car being partitioned off to serve as a sleeping room for two attendants. The machinery consisted of two double-acting ammonia compressors direct-connected to Diesel engines, ammonia condensers, a brine cooler, and two pumps for brine and for cooling-water circulation, respectively. A fan ventilator in connection with the condenser was set in operation when the train was standing, as otherwise the air passing through the louvres in the upper side walls of the car was not sufficient. A reservoir of cooling water was located beneath the car, as also were water-cooling radiators for the motors.

The Author's Earlier System of Mechanical Car Refrigeration

In 1913, when connected with the Canadian Pacific Railroad at Montreal as assistant to the general manager, the author began the study of mechanical refrigeration for railroad cars and built an absorption-system car, which was followed by two more cars constructed by him in the United States. The condenser and absorber were located underneath the car and the source of energy was a slow-burning charcoal fire.

Fig. 1 shows the arrangement of the machinery. The tank on the right is the secondary absorber, while on the left is placed the generator enclosed within an asbestos-insulated jacket. Resting on the generator is seen a portion of the charcoal magazine, which occupies the entire space across the upper end of the car and holds 1500 lb. of charcoal, or enough for twelve days' continuous operation. In the center on the floor is seen the specially constructed ammonia gas-driven circulating pump of the author's design. Above it is located the float regulator which controls the level of the liquor in the generator.

Fig. 2 shows the modifications later made in National Refrigerator Co. Car No. 1003. It was found necessary to add an analyzer and increase the temperature-exchanger capacity. Charcoal was

also abandoned as a fuel in favor of petroleum. The analyzer is shown at 26, while 63 is the secondary absorber, 57 the primary absorber, 67 the temperature exchanger, 35 the condenser, 18 the generator, and 25 the petroleum tank. Fig. 3 shows photographically the secondary absorber and temperature exchanger of Fig. 2.

The construction of the generator is shown in Fig. 5. This consisted of a conical coil of pipe surrounding a kettle hung by means of a trunnion and provided with one central large flue. The rich liquor was pumped into the conical coil first, and as the ammonia gas was distilled off it passed up through three take-offs from various points in the coil to a dome. The other end of the coil was led into the top of the kettle of the generator and there further fractional distillation carried on, the gas passing off through the dome to the analyzer and the condenser. A pipe led out from the generator kettle at the height it was desired to hold the weak-liquor level. This ran to the valve-controlling mechanism of the pump and thence to the power end of the pump, which was driven by the weak liquor and some additional gas.

Fig. 4 shows the general placement of the various elements of the apparatus. Underneath the car in the upper view is seen the absorber, while in the lower view—of the opposite side of the car—is seen the condenser. Within the car itself on the upper side walls are located the refrigerating coils, while the heater coils are positioned along both sides the lower sides of the side walls. On the roof of the car are placed the superheat-dissipating coils, and in one end of the car is located the operating mechanism.

This car operated successfully on one occasion for nine consecutive days without attention, standing still. The temperature was very evenly maintained at between 32 and 34 deg. fahr. and as low as 26 deg. was reached with an outside temperature of 80 deg. The car was empty.

Fig. 6 shows a diagrammatic plan of the process. Functioning as a refrigerator the operation is as follows: The charcoal magazine is first filled with crushed charcoal; the generator B is then filled with a rich charge of aqua ammonia and the secondary absorber to about one-third of its capacity. The fire being lighted, fractional distillation takes place and the gas thus expelled passes to the analyzer through pipe F, where a certain amount of dehydration takes place. The gas passes on to the condenser G and is liquefied in the header which connects to the automatic expansion valve H, the latter not opening until 15 lb. gage pressure has been reached. This retains enough pressure to start the pump automatically. The liquefied ammonia passes through the expansion valve and is expanded in the refrigerating coils I, I, passing from there to the absorber J. The weak liquor leaves the generator through the pipe K which projects into the kettle of the generator sufficiently high to obtain the minimum level of liquid desired. This hot weak liquor is conducted to the temperature exchanger L, where it meets the cold rich liquor coming from the absorber J and which is being pumped by the pump C. It gives up its heat to this rich hot liquor and is cooled by the countercurrent of cold strong liquor. It is then sprayed into the primary absorber N by means of a nozzle M and is further cooled by radiation by the coils O, O. It is thence conducted to the top of the absorber J and sprayed into this chamber. The pump is gas-and-weak-liquor driven and is controlled by the float regulator Q. The exhaust from the pump is conducted to a secondary counter-current temperature exchanger where most of its heat is absorbed by the cold rich liquor on its way to the primary temperature exchanger L, which liquor is finally conducted into the absorber tube N and thence taken up. The operation is continuous and automatic.

To convert the machine into a heater, the thermostat located

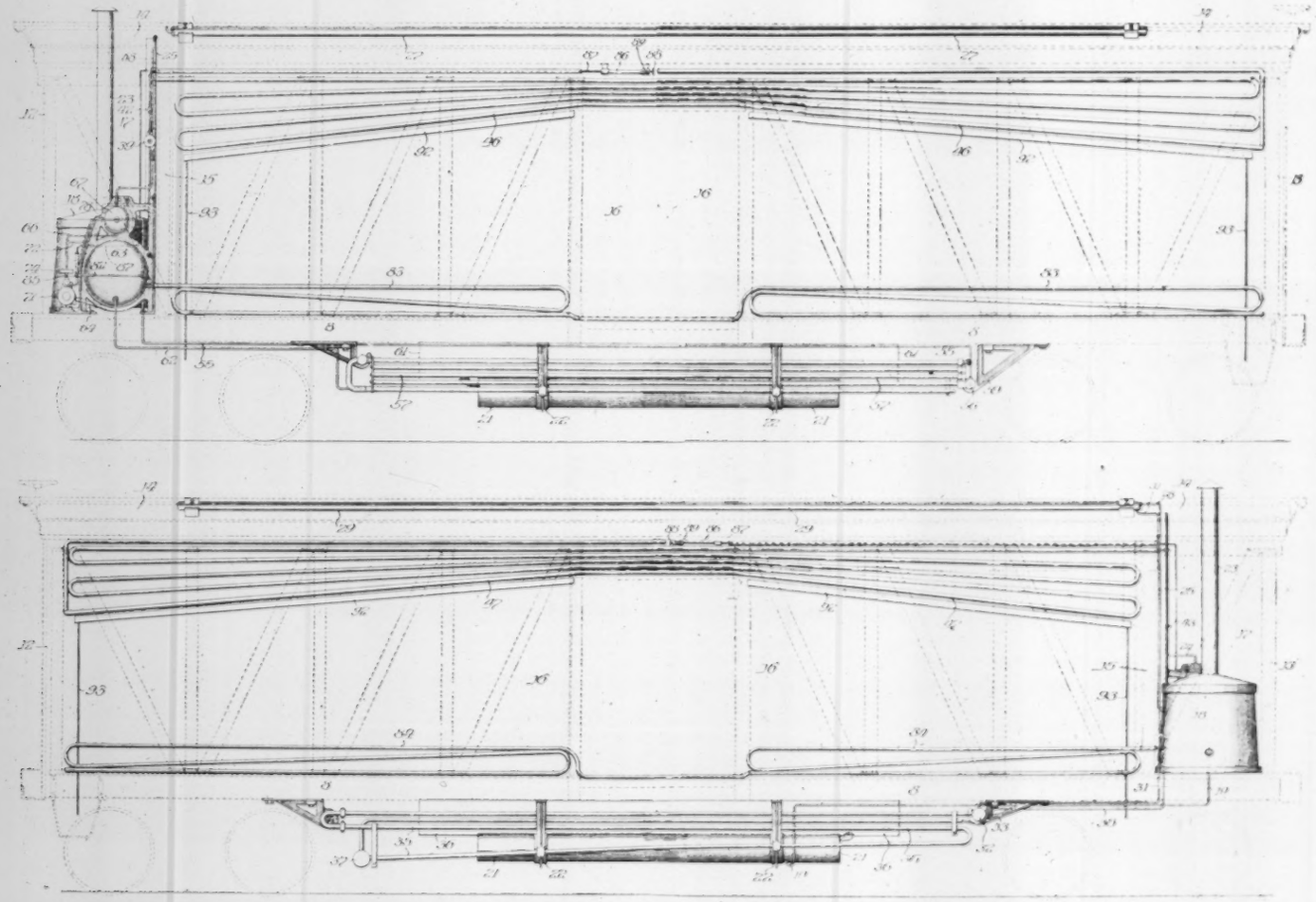

Fig. 4 General Arrangement of Apparatus of Car Equipped with Author's Absorption Refrigerating System

(Upper figure shows absorber underneath car; lower figure, of opposite side of car, shows condenser underneath car. Refrigerating coils are shown on upper side walls and heater coils at lower; superheat-dissipating coils on roof of car, operating mechanism at end.)

in the ceiling of the car functions the thermostatic valve. This opens a direct connection between the hot liquor of the generator and the heating coils *S*. After throwing off the heat imparted to the liquor by the fire, the fluid is conducted directly into the refrigerating coils, where additional heat of absorption by chemical action is further generated, assisting in warming the car, and the liquor passes on to the absorber in the usual way. The working of the machine is unaltered in all of its other operating functions. When the car has risen sufficiently in temperature the thermostat closes the thermostatic valve and the machine is again a refrigerator.

While this car from a construction point of view was a success in that it stood rough usage, met all the requirements of the Master Car Builders' Association, was cheap to build and economical in operation, nevertheless it was difficult to keep the pipe joints tight and leakproof. The real cause of failure, however, was due to boil-overs or foaming as soon as the car was switched or put in motion. The author devoted much time to this feature but was never able to prevent it. Of course, as soon as this occurred the car became inoperative, as liquor passed to the condenser and no anhydrous ammonia remained to expand in the refrigerating coils.

The Dense-Air System of Car Refrigeration

In 1917 the author abandoned all ammonia processes and attempted to achieve the result by means of the dense-air process. In this he has been quite successful. Fig. 7 shows a large refrigerated motor truck equipped with a one-ton dense-air refrigerating machine and having a capacity of 30,000 lb. of dressed beef at a load. The temperature maintained is 36 deg. on a 90-deg. day. A fleet of these trucks have been in continuous service for four years in the stockyards district of Chicago, handling traffic in a radius of 24 miles.

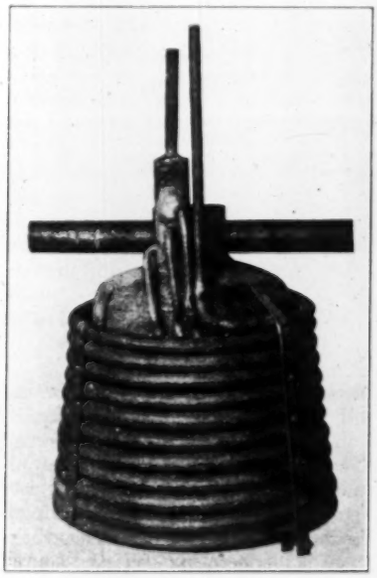

Fig. 5 Construction of Generator of Fig. 2

Fig. 8 shows diagrammatically the process as used on two of these trucks. The plant has a refrigerating capacity of 1000 lb. Its source of energy is a gasoline engine and the refrigerating medium is the air. With this combination the only operating supplies necessary are gasoline and oil. The refrigerating mechanism is located in a space occupying 2 ft. of the length of the body on the front end, leaving a receiving chamber for perishable goods 23 ft. 6 in. long, 7 ft. 4 in. wide, and 6 ft. 2 in. high. The refrigerating coils are located in the roof of the car and are fastened to the steel-plate and angle-iron carlines, which makes it possible to swing carcasses from the coils by meat hooks. The refrigerating machine is adjusted thermostatically to maintain the temperature of 36 deg. fahr. It can also be adjusted to reasonably lower room temperatures if desired, it being possible to carry the expanded air temperature of the refrigerating medium to 30 deg. below zero.

The Refrigerating Machine. The dense-air process is based upon the fact that a perfect gas under pressure, expanding adiabatically and performing external work will suffer a drop in temperature proportional to the mechanical energy produced. Its fundamental advantages lie in these characteristics: There is an unlimited supply of the agent everywhere, as air is the medium; it is readily dried by the use of deliquescent salts, it is innoxious, non-poisonous, and its explosive force lies only in its expansibility under pressure; a leak may be readily sealed and the air, once dried, becomes a perfect medium of refrigeration at temperatures much lower than is possible with any agent except CO_2.

The refrigerating unit consists of a compressor employing two cylinders (5 in. bore by 5 in. stroke), and an integral expander consisting of two cylinder ($4^3/_8$ in. bore by 5 in. stroke), both sets of cylinders operating from the same crankshaft. The unique feature of this design lies in the valve mechanism and means for controlling the expander unit. The exhaust valve is a rotary valve func-

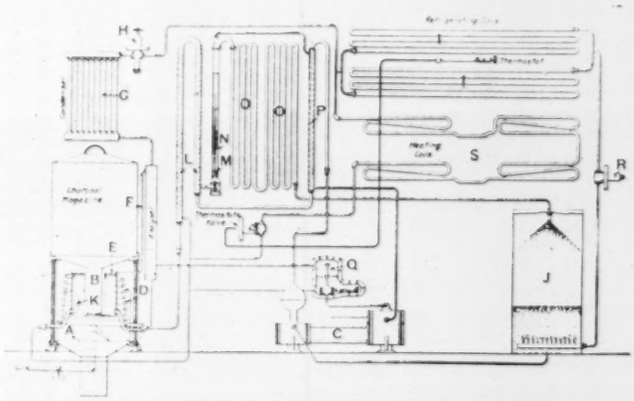

Fig. 6 Diagrammatic Plan of Car-Refrigerating System Shown in Figs. 2–5

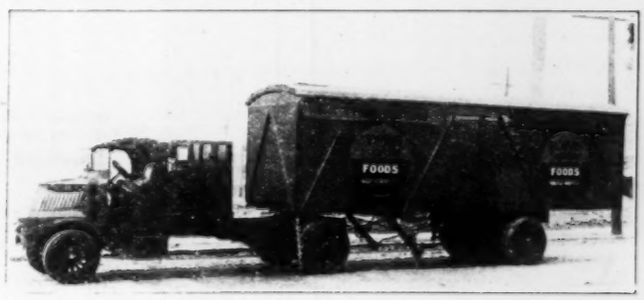

Fig. 7 Large Refrigerated Motor Truck Equipped with a One-Ton Dense-Air Refrigerating Machine

tioning both cylinders. The inlet valves are controlled and timed by a compound rotary cam whose length is adjustable by thermostatic control, thus making it possible to alter and control by thermostat the ratio of expansion, and therefore the resultant temperature. Castor oil is used as a lubricant in both the compressor and expander sides and the oiling system is in itself a closed cycle. The expander mechanism is oiled from the oil separator in the exhaust from the compressor and fed under pressure of the high side to the cams, valve mechanism and pistons of the expander. The compressor pistons are lubricated by splash from the crankcase and an oil separator in the low side returns the oil to the crankcase.

In operation the machine require $1^3/_4$ hp. which is furnished by an air-cooled engine of the Henderson motorcycle type. The engine also drives an exhaust fan of approximately 4000 cu. ft. capacity which produces a rapid flow of air across the compressed-air cooler, the compressor cylinders and gasoline engine cylinders. Proper ducts are provided to connect the various members to be cooled.

The Thermodynamic Cycle. In order to illustrate the system

and to set forth the simplicity of the refrigerating process and the incidental mechanism, attention is again called to Fig. 8 in which *A* is the refrigerating unit, *B* the gasoline engine which supplies the power, *C* the compressed-air cooler and *D* the refrigerating coils.

The device is primed by the use of the hand pump *E* connected with the drier *F*, operation of the hand pump being continued until the gage indicates the density required, as the capacity of the machine depends upon the densities of the two sides, regardless of the ration of expansion. Priming, therefore, is necessary to increase the relative capacity of the device.

In operation the compressor cylinders *G* take air through their pistons from the crankcase and discharge into the cooler *C* first through the oil separator *H*, thence through the drier *F* which removes the entrained moisture, converting the hydrous content into a fixed brine and allowing the anhydrous air to pass on to the cooler *C* where the thermal coefficient of the mechanical energy performed and the specific heat due to change in volume are removed, the cooler serving to bring the temperature of the compressed air down to a point approximately 27 deg. higher than the weather temperature of the day.

The compressed air which has been cooled now passes through

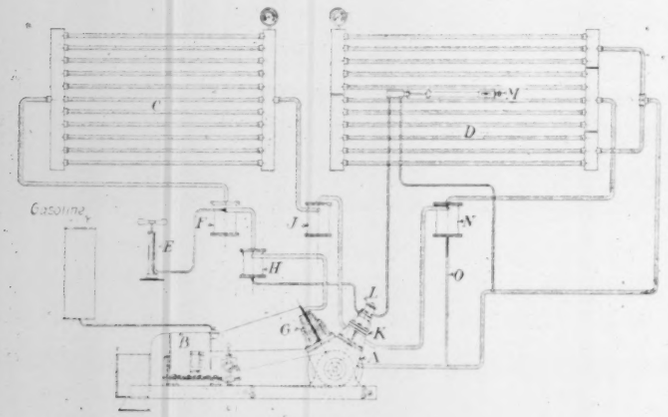

Fig. 8 Diagram Showing Process Employed on Motor Truck of Fig. 7

the secondary drier *J* to the expander, the secondary drier serving as a precautionary device to remove any moisture which may have passed the drier *F* because of high temperature at that point. In the expander *K* the air is expanded adiabatically at the ratio of expansion determined by the position of the control piston in the cylinder *L*, which is in turn controlled by the thermostat *M*. The expanded air, of extremely low temperature, is carried to the oil separator *N* in which any oil is removed before it may enter the refrigerating coils *D*, as oil in the coils produces a decided loss in efficiency. The oil extracted in the separator *N* is returned to the return pipe from the refrigerating coils *D* by a crossover *O*, both oil and air being finally returned to the crankcase from which the compressor cylinders take their supply.

The thermostatic control of the ratio of expansion is accomplished by means of a piston whose position determines the length of the cam face, which in turn determines the proportionate time of opening and closing the inlet valves, and therefore the ratio of expansion. The position of the control piston is determined thermostatically by a leak-off connected with the thermostat, by which high-pressure air is allowed to escape to the low-pressure side and move the piston proportionately to its rate of escape.

In a device having extremes of temperature such as the one under consideration it is highly important that lubrication be effective and automatic. Castor oil is used because of the fact that its viscosity is not greatly affected by either the high temperature of the compressor or the extremely low temperature of the expander. The compressor cylinders take their air from the crankcase and lubrication of the compressor cylinders is effected by the splash of the crank. It follows that a comparatively large amount of oil is carried with the air into the compressor cylinders, where not only the cylinders but the valves and valve mechanism are amply lubricated. This oil is separated from the compressed air by the separator *H*, and being under the pressure of the high side is fed through a tube to the cam pocket and valve head of the expander mechanism. This constitutes a crossover for the oil. Some portion escapes around the pistons into the crankcase. The remainder is carried with the expanded air to the separator *N* where it is removed centrifugally and by-passed and returned through the tube *O*.

The Ethyl Chloride System

In addition to the systems described there is another, of the compression type, using ethyl chloride as the medium. Ethyl chloride boils at 54.5 deg. fahr. and liquefies at the low pressure of 15 lb., with condenser water at 65 deg. fahr. Its critical temperature is 365 deg. fahr., which is sufficiently high to preclude the danger of generating permanent gases. Being a neutral gas, it is possible to use thin seamless drawn copper tubes, and the joints may be soldered if desired.

As the boiling point of ethyl chloride is so low, a partial vacuum is necessary on the low side of the machine to produce the required temperature in the car. The medium is handled by a valveless rotary compressor.

The machinery is located in the end of the car and the method of operation is as follows: The medium is evaporated in the refrigerator pipes in the refrigerating compartment. The gas is then drawn to the compressor and forced into the condenser where it is liquefied. The condenser consists of a series of copper tubes placed vertically in the compartment with the compressor. The heat of compression is removed by means of a small spray of water fed to the top of the condenser, and this water is cooled by a fan so arranged that the current of air is distributed equally over the entire surface of the condenser. The power to drive this mechanism is taken from the axle of the car by means of a belt and countershaft below the compressor. Between the countershaft and the truck axle are interposed two idler pulleys upon a common guide, these pulleys being held together by springs and placed upon a guide in order that they may operate in either direction. The arrangement is such that in whichever direction the car is running the machine automatically takes up its refrigerating work. The water for cooling the condenser is carried in a tank underneath the car, from which it is pumped by a small rotary pump attached to the main shaft of the compressor. An oil engine is provided for the purpose of continuing the operation of refrigeration when the car is standing still, thus making it possible to set the car out of the train when necessary. The water for cooling the cylinder of the engine is carried in a small tank on the roof of the car.

Conclusion

As stated at the beginning of the paper and for the reasons there mentioned, it will be some time before mechanical refrigeration will be adopted on American railway cars. However, the author believes that it can be accomplished by equipping refrigerator cars with a thermosiphon system and providing a tank in the roof of the car with two compartments, one for receiving ice from regular icing stations and the other for holding a weak brine solution into which is submerged a refrigerating coil; the source of energy for cooling this brine to come from a central refrigerating-plant car carried in the train and having a capacity sufficient to refrigerate ten cars. The brine cooled in this central car would be pumped under a pressure of two or three pounds to the refrigerating coils in the various refrigerator cars, and even remove the latent heat of the brine in the tanks, if necessary, thus freezing it, thereby storing refrigerating work to be used if the car should be set out; or if the car is to be used in traffic where it is not operated from the central-plant car, then, as previously mentioned, it may be iced in the usual way, and by means of the thermosiphon system a rapid automatic circulation of the secondary refrigerating coils will take place whether the car is standing or in motion. It should be possible to store enough latent-heat energy to operate one of these cars at least 72 hours without re-icing or reconnection to the central-plant car.

This central-plant car should have installed within it a dense-air refrigerating machine of 30 tons refrigerating capacity for a ten-car unit. This machine may be driven by any of the standard forms of gas or oil engines, preferably of the Diesel type, and the entire operation can be so designed that no water need be provided to carry away the heat of compression.

The Helicopter and the Variable Pitch Propeller

Notes on Some of the Problems That Are Involved and the Present Situation of Development, Particularly in the United States

THE helicopter differs from the aeroplane in that it obtains its lift directly from the propellers and not through a component of resistance of the air acting on planes inclined at an angle to the direction of the motion of the machine.

The helicopter idea is at least as old as, if not older than, that of the aeroplane, and toy helicopters flew long before Langley and the Wright brothers. The fact that the aeroplane reached practical developments long before the helicopter is, however, due to the much greater difficulty of the solution of the latter problem.

The immediate advantage of the helicopter over the aeroplane is uncertain, depending in the end on its development. Its most important apparent advantage is its ability to rise vertically from a standing start and to hover over a given spot. On the other hand, at least as far as the helicopter has been developed to date, it would appear that its ability to maintain itself in the air is entirely dependent on the engine, and should the latter stop, the helicopter would come down like a stone. Commander J. C. Hunsaker, Aircraft Division, U. S. Navy, was asked whether he considered the present aircraft engine sufficiently reliable for the hazardous service of helicopter flying and he emphatically stated that he did not. We shall see later the ways by which it is attempted to increase the safety of the helicopter in this respect.

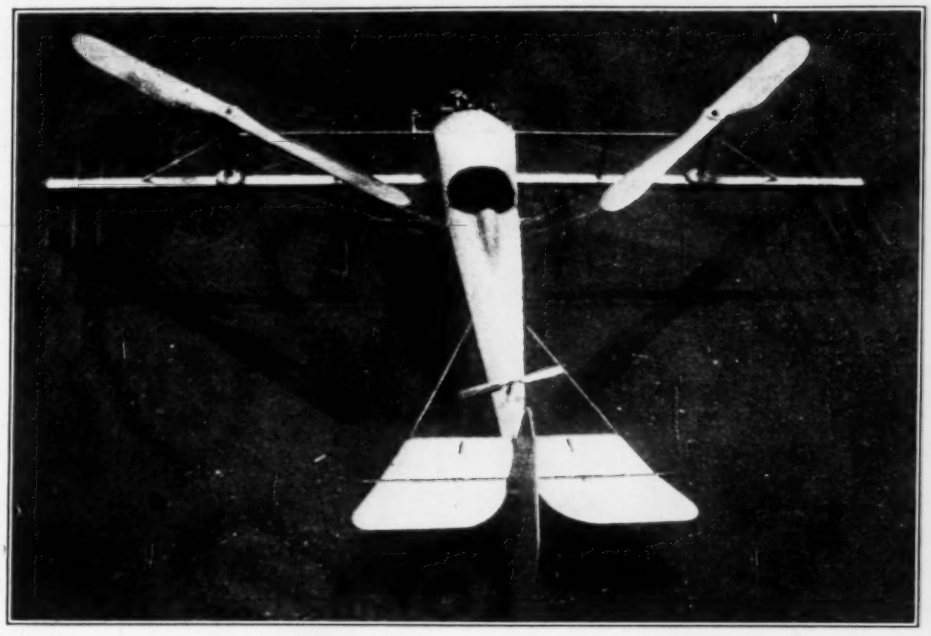

FIG. 1 THE BERLINER HELICOPTER

THE FOUR HELICOPTER PROBLEMS

The riddle of the helicopter may be considered as comprising four different problems. The first is that of getting off the ground. This is the simplest and easiest part. With modern large propellers a lift of 15 lb. per horsepower can be easily obtained and as aircraft engines weigh around 2 lb. per horsepower, there is ample margin for the weight of the structure, pilot and supplies for a flight of considerable duration.

The question of getting safely back to the ground in case of engine failure is much more difficult. An aeroplane volplanes; the conventional helicopter would drop like a stone. Several unworkable devices have been suggested, such as the use of parachutes, balloons, etc. The most promising suggestions to date appear to be the use of propellers with extremely wide blades (Damblanc, Fig. 2), the angles of which may be changed so that the propeller would spin like a windmill driven by the air pressure during the descent. With propellers of proper size and design the velocity of descent might be considerably retarded, but would still remain too high to be either safe or comfortable. Another proposal (Leinweber Brothers) involves the use of planes somewhat like those in an aeroplane built up of movable shutters affording large openings during the ascent but acting practically like aeroplane planes during the descent. Whether such a construction will prove practical with the increased weight and mechanical complications, only time will show.

The next problem is that of keeping the helicopter right side up. In the Petroczy-Karman helicopter stability is insured by tethering the helicopter to the ground by cables. This, of course, can be done only with captive helicopters. In the Leinweber helicopter the control of position is secured by varying the angle of the propeller shafts (Fig. 3) with the axis of the machine. Proper balance can undoubtedly be secured in this way, providing the methods of control are sensitive enough.

In the Berliner helicopter (Fig. 1) control is secured by the use of three movable fins under each of the propellers, movable about in the stream of air projected by the propeller. The longitudinal control is secured by the little variable pitch propeller shown in the rear of the fuselage of the machine. In the Damblanc helicopter, control is secured by varying the angle of any of the blades of either propeller independently of the rest. In this way more lift can be secured from one side of the helicopter than from the other. Here again the balance will depend on the sensitiveness of the controls and also on the natural tendency of the machine towards positive or negative stability.

If the above three problems were properly solved the helicopter would be capable of rising, hovering, and coming down. To make it a transportation device it must also become capable of horizontal travel in any desired direction. This can be obtained either by tilting the whole helicopter so that the propellers pull it both forward and upward (which is accomplished in the Berliner helicopter by the use of the little variable pitch propeller), or by the use of an auxiliary propeller for horizontal drive, or, finally, by varying the pitch of the propellers as suggested by the Leinweber Brothers.

SOME FOREIGN HELICOPTERS

As regards helicopters of which the development has advanced far enough to give a fair idea of their construction, it should be stated at the outset that the information available is somewhat sketchy. The designers of some of the helicopters, for example, Brennan, in England, have absolutely refused to give any information to the public. Others have permitted inspection of their machines and given information but with material reservations.

Helicopters attracted some attention of Austrian army authorities as a means of replacing captive balloons for observation purposes. Helicopters, if properly developed, might prove to be quite valuable for this purpose, since in the first place they offer a much poorer target to enemy fire, and second, have fewer vital points to be hit and are not inflammable. Because of this, during the recent war, Lieutenant Petroczy and Professor Karman were authorized to build captive helicopters, one of which was equipped with electric power and the other with two LeRhone motors. The total weight of the captive helicopter and fuel for one hour,

but not including the observer, is about 1300 kg. (2860 lb.) After about 15 successive flight tests lasting up to an hour, at wind velocities up to 8 m. (26.3 ft.) per sec., the machine had a breakdown in landing. Observations proved that in addition to the fundamental demand for ample excess of thrust, the position of the center of gravity in its relation to the plane of rotation of the propeller is of great importance.

In the Karman helicopter the propellers are superimposed.

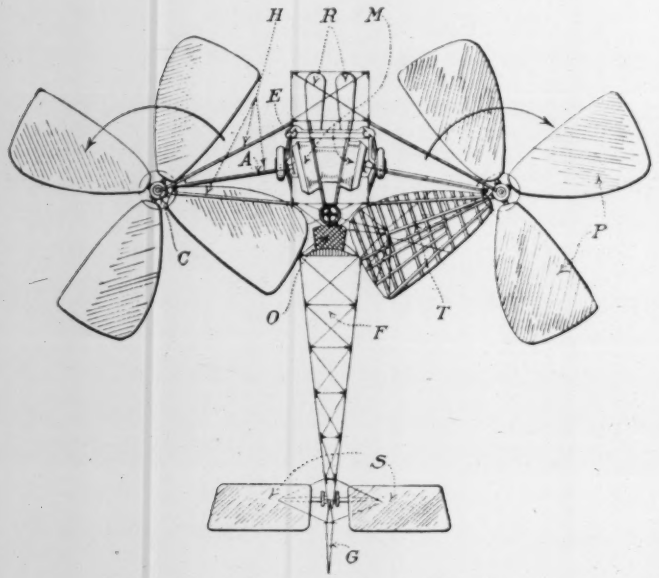

FIG. 2 THE DAMBLANC HELICOPTER

In the Damblanc helicopter (France) (Fig. 2) there are two rotating wings, each formed of four blades having an area of about 5 sq. m. (53.8 ft.) In addition to this there are two stabilizing planes situated to the rear of the fuselage and controlled by a metallic cable. There is an interesting warping gear for the blades comprising articulated elbow levers acting on the blades of the wings by means of metal cables operated from a control stick. The total area of rotating wings is 40 sq. m. (131 sq. ft.) and the speed of rotation 160 r.p.m.; the weight per square meter of lifting service is 30 kg. (6.2 lb. per sq. ft.) So far as information is available only laboratory tests on this machine have been made.

In the Oemichen-Peugot machine (France) sustentation is partially derived from a hydrogen-filled balloon of fair size. It has two lifting screws driven by belts and disposed symmetrically on the upper part. The screws are each formed with two blades of a special profile, very large towards the root and very thin towards the tips. Their diameter is 21 ft. The machine is driven by a motor developing 25 hp. and weighs 740 lb. The balloon supplies a net lift of 156 lb., while the propellers have to deliver a lift of 495 lb. which is quite a good deal for a motor of 25 hp.

AMERICAN HELICOPTER DESIGNS

A good deal of valuable work, both development and research, is being carried on on this problem in the United States. The National Advisory Committee for Aeronautics just completed an extensive investigation of some features bearing on the helicopter problem.

Of the machines actually constructed in this country may be mentioned the helicopters built by Emil Berliner and his son Henry, in Washington, D.C., the Leinweber Brothers in Chicago, Ill., and the late Peter Cooper Hewitt, in association with Prof. F. B. Crocker. Of these the Berliner machine has two main propellers 14 ft. 10 in. in diameter running at 540 r.p.m. and an auxiliary control variable pitch propeller 3 ft. in diameter, running at 1700 to 1800 r.p.m. The machine is driven by a 110 hp. LeRhone motor and weighs complete with pilot and fuel from 1350 to 1400 lb. Henry Berliner stated that all the flights undertaken hitherto have been made at comparatively low altitudes, around 6 ft. and not to exceed 20 ft., this being done mainly in order to avoid unnecessary danger during the experimental period. He also stated that flights were made in a horizontal direction to the extent of several hundred yards.

The Leinweber Brothers machine has so far flown only in the vertical direction, being used for experimental purposes, merely as a captive helicopter. Its main features of construction appear fairly well from the photograph (Fig. 3).

It has a length 25 ft., width from propeller tip to tip 22 ft., weight 1500 lb.; uses two Gnome engines of 100 hp. each, two 10-ft. propellers and also four three-bladed propellers size 2–9 ft. 6″ on top and 2–6 ft. propellers at the bottom. In addition to that, however, the designers have developed a system of control for the propellers operating essentially in the following manner:

The active members of the control consist of two weights freely suspended as pendulums each operating a four-way valve controlling a compressed-air motor, which, in its turn, regulates the position of the shafts carrying the propeller blades. The device is somewhat similar to numerous devices used in aeroplane stabilizers where, however, their operation is apt to be considerably disturbed by centrifugal force arising when an aeroplane makes a sharp turn. When this fact was mentioned to William Leinweber he agreed with the possibility of it, but stated that the helicopter would not be supposed to take as sharp turns as an aeroplane.

An American design which attracted a good deal of attention towards the end of the war was the Hewitt-Crocker helicopter, jointly developed by the late Peter Cooper Hewitt and Prof. Francis Bacon Crocker. In this machine there are two propellers, an upper propeller revolving in a normally horizontal plane and another propeller revolving in a parallel plane 7 ft. below, each propeller being 51 ft. in diameter. The motor speed is 1400 r.p.m. and the propeller speed 100 r.p.m. which means a speed reduction of 14 to 1, this being obtained by a gear train consisting of a gear 30 in. in diameter and a pinion 2 in. in diameter. The gears are designed so as to avoid their springing out of mesh. The propeller blades of the Hewitt-Crocker helicopters have the form of aeroplane wings, not only in cross section but also in aspect ratio and other proportions. The actual section of the propeller blades is Eiffel No. 63, the thickness of which is one-tenth of the chord. The width of the blade is 30 in. and the thickness 3 in. This section and these dimensions are uniform throughout the length of a blade which is 12 ft.

For turning the machine so as to enable it to face in different directions two planes are provided, located at the extremities of two arms. These planes are capable of being tilted about a horizontal axis passing through their centers, and are located below the

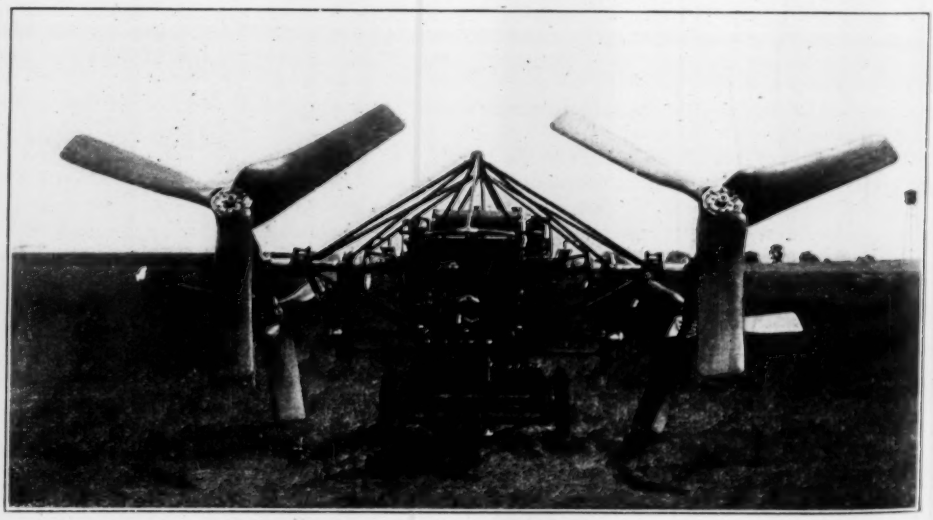

FIG. 3 THE LEINWEBER HELICOPTER

propeller blades so as to receive the downdraft therefrom. These planes may be used to correct any tendency of the car to rotate as a result of unequal action of the propellers.

THE VARIABLE PITCH PROPELLER

The development work on the helicopter is likely to lead to an intensive interest in the improvement of the variable pitch propeller. In the first place, variable pitch propellers are already used on some of the helicopters, as, for example, in the auxiliary propeller of the Berliner machine and the main propellers of the Damblanc machine. In the next place, one of the main advantages of the helicopter lies in its ability to rise and descend vertically though this latter cannot yet be considered to have been accomplished to any material extent. The aeroplane of today requires, on the other hand, quite a considerable field for rising and landing, and with many designs can effect a landing only at high speeds, which makes the operation of landing to a certain extent more hazardous than average flying. If, however, really reliable and easily operated variable pitch propellers were available, the landing speeds on aeroplanes could be cut at least in half. This is exemplified by tests made at McCook Field, Air Service, War Department, with machines equipped with the Dicks steel variable pitch propeller. In landings with the propeller at constant pitch the machine came to a full stop in 625 ft. and the same machine landed in 239 ft. when the variable pitch propeller was used. In this way the aeroplane is given one more chance to defend its position against possible competition on the part of the helicopter, providing this latter should be developed to the commercial stage.

Of course, variable pitch propellers are also of great importance in connection with high altitude flying, which is likely to become a feature of aerial transportation of the future. There, the value of the variable pitch propeller lies in the following: The engine loses power with elevation, because of the reduced content of oxygen in the volume of air inducted into the cylinders, and the resultant ability to burn less fuel. In other words, the engine at higher altitudes acts as if it were partially throttled. Supercharger devices precompress the air delivered into the induction system of the engine and in this way restore the engine power delivered to the propeller. Since, however, the medium in which the propeller operates is of reduced density, the increase in speed by itself does not produce a corresponding increase in thrust, unless the propeller pitch is varied. Because of this the variable pitch propeller becomes a natural adjunct to the supercharged aeroplane engine.

The problem of the variable pitch propeller is quite simple at first glance, it being only necessary to provide some kind of a gear device to turn the blades about their longitudinal axis. The difficulty of the problem lies, however, in the fact that in a variable pitch propeller, the blades must be separate from the hub. At the same time, the stresses induced by centrifugal forces in the propeller are so high that it becomes extremely difficult to secure a method of connection between the propeller hub and the blades that could withstand these stresses. During the war Mr. Hart of California developed a wooden blade propeller having the variable pitch feature. This propeller was taken over by the Air Service, War Department, and a great deal of experimental Work and design was applied to it at McCook Field with what are said to be highly gratifying results.

Of late an all-metal variable pitch propeller has been developed, a problem of considerable difficulty, as it was believed that structures operating under the conditions of aeroplane propellers and made up of steel would be subject to crystallization of the metal and subsequent failure.

The Dicks propeller developed by Thomas A. Dicks of Pittsburgh is shown in Figs. 4 and 5 as mounted on an aeroplane at McCook Field. It is said to be the only variable pitch propeller actually operated on the 12-cylinder Liberty motor. The blades of the Dicks propeller are machined out of a special alloy steel so as to fit over a taper mandrel. A series of specially designed reamers are used to give each section the exact dimensions. The blade is then compressed to size over a series of mandrels. The gear for turning the blades and thus varying the pitch is shown in the illustration. An interesting arrangement for holding the blades in the hub is used, not subject to publication at the present time.

In flight tests on a DH plane with Liberty motor, the same speed was developed with the variable pitch steel propeller as with the permanent pitch wooden propeller, but the ground run on landing was cut practically in half. The Dicks propeller is somewhat heavier than the standard wooden propeller, which, under certain conditions, may prove to be a handicap by displacing the center of gravity too far forward. If it should prove to be possible to use lighter alloys, such as duralumin, for the blades, instead of steel as at present, not only the weight of the unit but the centrifugal stresses produced by the blades on the hubs and connections would be materially reduced.

A special system of controls has been developed for this propeller, as well as means for regulating the carburetor throttle in conjunction with the variations of the propeller pitch. These cannot be described at the present time.

FIG. 4 DICKS VARIABLE PITCH STEEL PROPELLER

DEVELOPMENT PROBLEMS OF THE HELICOPTER

Coming back to the question as to the probable field of application of helicopters, one must start with a clear understanding that any prediction as to this must be made dependent on the development of the helicopter. Thus, for example, the question of safety of flight will play an important part, as well as the ability of the machine to land on extremely restricted grounds. This latter, together with the ability of the helicopter to hover, might make it extremely valuable for military purposes for operation in connection with the Navy, as well as for commercial purposes, by enabling the helicopters to act as connecting links between ships at sea, a service which aeroplanes tried to perform, but for which they have not hitherto proved entirely suitable.

On the other hand, however, engine failure, as has been stated above, would leave the helicopter powerless against the action of gravity. There is, of course, a simple remedy to meet this situation applicable, however, only to large machines, and that is, to use more than one engine. Thus, for example, the Leinweber Brothers state that they are designing a helicopter that would use 12 engines, while Professor Crocker is willing to compromise

on the more modest number of four engines. There are good reasons to believe that helicopters if they become at all available in any form similar to that of the machines now being built would be primarily a large size machine of a type where at least two, probably four, engines might be legitimately used.

Whatever may be the development of the helicopter, there is no doubt as to its value in giving us a better understanding of aerodynamic phenomena, and, in particular, of the operation of large-diameter comparatively-slow-revolution propellers.

In this connection, Edward P. Warner, of the National Advisory Committee for Aeronautics, points out as a curious fact that whereas the aeroplane has been developed almost entirely by young men not previously noted as inventors, engineers, or scientists, the fortunes of the helicopter have been more in the hands of those with reputations previously acquired in other fields. Mr. Edison has long been a believer in the future of the helicopter as the best means of air transportation and some of the important contribu-

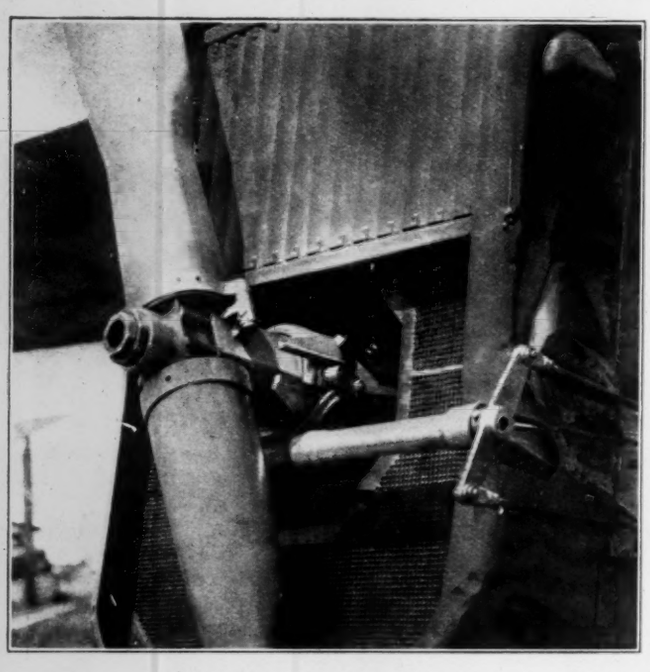

Fig. 5 The Dicks Variable Pitch Propeller Partly Showing External Gear for Moving Blades

tions to helicopter design and invention in America have been made by the late Peter Cooper Hewitt, the inventor of the mercury arc light, and by Doctor Berliner, originally responsible for the disc talking machine. In England, important work is being done by Brennan, known as the inventor of the monorail railroad. This may perhaps be explained to a certain extent by assuming that the majority of men of achievement in the nineteenth century "knew" that aeroplane flight was impossible and therefore did not bother with it, leaving the field to visionaries like Santos Dumont and the Wright brothers. There is no question today that sooner or later a workable helicopter will be built and that it is merely a matter of design, additional information and perhaps a leaven of mechanical genius that are necessary to solve the problem, and the problem itself is big enough to be attractive to men who have already won their spurs in other fields of achievement.

There are three sets of problems that confront the designers of helicopters of the future. The first are of a purely mechanical character. Variable pitch propellers, method of installing and holding large propellers, layout of the helicopter frame subject to heavy stresses, and yet so different from the aeroplane frame, and the thousand and one details involved in this novel structure will tax the mechanical skill of the designer. As in the case of the aeroplane, this is going to be a matter of slow development, the designers learning by previous failures, and while a great amount of ingenuity will be needed, there does not seem to be anything that would be impossible of solution.

The next great problem before the designers of the helicopter of the future will be to secure the scientific information necessary. It is not so much the genius of aeronautical engineers that made the present plane so safe, efficient and powerful, as compared with the flimsy machines of 1908 and 1909 but the immense amount of aerodynamical information gathered in such laboratories as the Eiffel, National Physical at Teddington and numerous wind tunnels in America. Some of this information will of course prove applicable to helicopter design but the conditions of operation of the helicopter and the elements of its construction are so different from those incorporated in aeroplanes that a vast amount of additional information will be needed. Thus for example, we have learned in the last ten years from numberless tests on the stand, in the wind tunnels, and in actual flight a good deal about the laws governing the performance of comparatively small high-speed permanent pitch propellers, but we have only scant and uncertain knowledge as to the operation of large low-speed propellers and still less as to the effect of slight variations of pitch under different conditions of operation.

It is a fortunate matter as far as the United States is concerned that we have in this country at present research facilities that can hardly be matched by any other country in the world. The wind tunnels at Massachusetts Institute of Technology, Langley Field, McCook Field, Leland Stanford, Jr. University, not to mention smaller institutions, are excellently equipped, and what is more important manned by engineering staffs who have already shown their ability to carry on difficult path-bearing research in a highly skilled manner. In the development of aeronautical instruments and methods of investigation the United States probably leads the world. Just as an instance might be mentioned the fact that under the auspices of the National Advisory Committee for Aeronautics there have been developed recently methods for determining the pressure on every part of an aeroplane in actual flight which will rapidly eliminate the great uncertainty still prevailing as to this important factor.

The development of the helicopter is also apt to bring about changes in engine design. Most of our aeroplane engine design is still under the influence of war conditions. For military purposes single machines of maximum output for a given plan are preferable to multiple units because while single machines carry a lower general factor of safety they have a higher military factor of safety, the idea being that if one of two machines fails the flyer under actual conditions would still be able to safely reach the ground with the other engine. Under war conditions, however, the failure of a single engine would reduce the safety of the plane so as to place the flyer at the mercy of his faster adversary.

Helicopter conditions of operation from the engine point of view are, however, vastly different. As far as one can see now the safety of helicopter flight will depend on engine performace although of course unforseen developments in design can meet these conditions in a manner of which we know nothing about today. As far as we can see now, however, if the engine power of the helicopter should stop the machine would come down to the ground faster than would be desired from the point of view of at least comfort if not safety of the flyers. It has been suggested already that this difficulty might be at least partially solved by using multiple units, e.g., by Professor Francis Bacon Crocker who suggested the use of four engines.

It is an interesting fact that while important progress has been made in the design of large aeroplane engines, the field of smaller engines has been comparatively neglected and it is rather significant that practically all experimenters with helicopters are using engines dating to the early days of the war, the favorite in America being the LeRhone 110-hp. rotary.

If multiple units are to be used on helicopters these units will be comparatively small which will mean a demand for small, light and yet efficient units. Some work in this direction, called forth however by a different set of conditions, is being done already. Small engines with an output of not to exceed 60 hp. are being vigorously developed in Germany, one having been placed on the market last spring by the Siemens-Halske Company. The interest of the Germans in small engines is due to the fact that for the next two years at least, beginning with May, 1922, no civilian machines will be permitted to fly in Germany under the Treaty of Versailles if powered with more than 60 hp.

Acid-Resisting Metals and Alloys

An Account of Research Work Carried Out on Various Non-Ferrous Metals and Alloys, with Especial Reference to Their Use in the Manufacture of Mine Pumps and Chemical Apparatus

By GEORGE A. DRYSDALE,[1] INDIANAPOLIS, IND.

FOR many years past, there has been a great demand for true acid-resisting metals, more especially in the chemical and coal-mining industries. In fact, their production has become one of the great metallurgical problems of the day, for up to the present time no metal or alloy giving satisfactory results, in a broad sense of the term, has been discovered. However, a great deal of thought is now being given to the subject and much experimental work is being carried on by large manufacturing corporations interested in developing such metals. Also the United States Government, through its Bureau of Mines at Pittsburgh, Pa., is conducting a series of tests on the various known metals and alloys, to determine their acid-resisting properties.

Wherever ferrous or non-ferrous metals are used, attacking or destructive agencies in the nature of oxidation, corrosion, erosion, etc., are always present and have their detrimental effects in varying degrees. Mine pumps and apparatus for chemical industries have been made of either steel, cast iron, brass, bronze, lead, or a combination of these metals. Brass and bronze, under ordinary working conditions, have been found in the majority of cases to be superior to steel or cast iron, and lead or antimonial lead superior to brass or bronze. However, none of the metals mentioned gives satisfaction when used in the manufacture of mine pumps; in other words, none of them will stand up for a reasonable period of time against corrosion and erosion.

Conditions Governing the Production of Practicable Acid-Resisting Metals and Alloys

It is common knowledge that an alloy containing approximately equal parts of cobalt and tin is practically acid-proof (aqua regia included), but such an alloy would be too brittle for mine pumps or chemical apparatus, and its cost would be almost prohibitive. Alloys of copper, nickel and tungsten are also highly resistant to sulphuric acid in different strengths; high-silicon ferrous alloys (14 to 15 per cent Si) are also resistant to sulphuric, nitric and other acids, but on account of their excessive hardness and brittleness their use is limited, and therefore none of them complies with the four major conditions which must be the basis of consideration in perfecting a true acid-resisting metal and placing it on a commercial basis. These conditions are:

1 The metal or alloy must be good from the foundry standpoint—a metal or a perfect alloy that gives a very dense structure, is free from a tendency toward segregation on cooling, pours well, does not excessively oxidize in melting, does not burn the sand in pouring, takes a good impression of the mold, has a normal shrinkage, and makes castings that are easily cleanable.

2 The metal or alloy must machine well and not be too hard. Some acid-resisting metals, especially ferrous, pour well but are too hard and brittle to machine, and consequently their field of usefulness is limited.

3 The metal or alloy must have certain physical properties which are under control and which enable the manufacturer to comply with any reasonable specifications that may be called for, such as degrees of toughness, malleability and strength.

4 Such a metal or alloy in the form of castings, bar stock, plates, etc., must be reasonable in price. Therefore, outside the cost of the virgin metal used for such a metal or alloy, the other three major conditions have a great deal to do with the cost of the parts made.

Three or more years ago the Midwest Engine Company requested its metallurgical department, of which the author has charge, to conduct experimental work for the purpose of developing an acid-resisting metal for use in pumps which the company supplied to coal mines in the anthracite and bituminous regions; consequently the tests dealt more especially with sulphuric acid. Heretofore most of the pumps were made of so-called acid-resisting bronzes, but their life was short, especially in certain districts where the mine water was very bad. For example, in mine waters with free acid (as sulphuric) ranging from 13.67 grains per gallon in one particular instance to 91.96 grains in another, and mineral matter from 74 grains per gallon to 479 grains, it is with apparent difficulty that these mines retain a pump in good working condition for any reasonable length of time, withstanding the action of the acid and also the erosion from mineral solids in suspension in the water. Laboratory tests were therefore started with the purpose of finding a metal or alloy that would comply with the four major conditions stated above.

Experience along these lines first taught the author that when comparative tests are run on acid-resisting metals, it is best to divide the samples into three classes, namely: rolled and drawn stock; that cast under pressure, using very heavy risers—these sometimes weighing more than the casting itself (which is expensive); and castings poured in the ordinary way or following along the lines of usual procedure in a brass foundry. This is done for the reason that widely different results are obtained both as to the acid-resisting qualities and the physical properties. As an example, an alloy well known under the trade name of monel metal may be cited. In testing out this metal in sulphuric acid of different strengths and temperatures, it was found that the degree of resistance was greater in the rolled and the cast-under-pressure stock than in the ordinary cast metal. The physical properties were high in the first and second instances, but low in the third. The average results from a number of test bars poured under pressure were as follows: Yield point, 37,000 lb. per sq. in.; ultimate tensile strength, 72,000 lb. per sq. in.; elongation in 2 in., 34 per cent; reduction in area, 32 per cent. When cast not under pressure the tensile strength was 25,750 lb., with low percentages of elongation and reduction in area. Monel metal gives the highest test results when poured under the highest pressure. This has also been noted with various other alloys, consequently it is now the practice of the company to only pay attention to the physical properties of test bars which give the true working conditions under which the castings are made. It has also been noticed that the rolled and drawn metal and that poured under pressure and with chills resist the corrosive and erosive action of mine water to a greater degree than do metals cast in the ordinary way. This is of course on account of the finer structure or closer grain in the former; in other words, when the cast metal is in the granular form, the corrosive action is much greater than when in the more dense or fibrous form of structure, where the penetration is naturally more difficult.

A very good example of the penetration and absorption of an acid solution in a coarse-grained metal, and the care which must be exercised to eliminate, before weighing, any salts or adherent acid, is a sample of an acid-resisting metal that was immersed in a concentrated solution of sulphuric acid for 500 hours. When the test was completed the sample was removed from the solution, carefully washed in the usual manner in distilled water, and weighed. The loss in corrosion was 1.400 per cent. However, within 24 hours after this weighing the dry sample showed a slight incrustation of sulphates on the surface. It was then placed in a beaker of distilled water where it remained for 24 hours to remove any remaining acid or salt formation. The water at the end of this time was distinctly acid, and when the sample was again dried and weighed the loss from the original weight was 2.003 per cent, the difference from the first weight after the test being 0.543 per cent. As this instance demonstrates, great care must be exercised to obtain a

[1] Metallurgical Dept., Midwest Engine Co. Mem. Am.Soc.M.E.

Presented at a meeting of the Indianapolis Section of The American Society of Mechanical Engineers, Indianapolis, Ind., October, 28, 1921. Slightly abridged. All papers are subject to revision.

clean sample after tests are made, otherwise the results obtained will be incorrect. It also demonstrates the fact that this particular piece had an exceedingly open or coarse structure at the center, or perhaps some segregation.

Acid-Resisting Qualities Due Largely to Fineness of Grain

In consequence, the conclusion has been reached that the structure or grain of the metal or alloy is the major point in its acid-resisting qualities. This applies to ferrous and non-ferrous metals alike. With metals such as copper, tin, lead, zinc, nickel, antimony, etc., their structure may be referred to as dense and, in most instances, *fibrous;* while the cast alloys made up of these metals may be referred to as fine, medium or coarse *grained* in the majority of cases; and because of this coarseness of grain many acid-resisting alloys do not work out satisfactorily. It has also been found that the different alloys when poured in a chill mold resist the action of corrosion and erosion to a greater extent than when poured in a green mold; and when poured in a green-sand mold, more than in a dry mold. In the first instance the grain is finer than in the second, and in the second instance finer than in the third. As an example of the difference in their resistance to acid, in testing the metals separately, virgin copper, when placed in concentrated sulphuric acid (sp. gr. 1.84, 66 deg. B.), at room temperature, was readily attacked within 24 hours; when placed in a 30 per cent solution (sp. gr. 1.224, 26.5 deg. B.) the action in 30 days was almost negligible, and in a solution of 10 per cent sulphuric acid (sp. gr. 1.070, 9.5 deg. B.) the action in 30 days was very slight. The same conditions were found to exist with nickel, tin and antimony. Zinc was readily attacked by concentrated sulphuric acid, however, more especially so in the 30 per cent and 10 per cent solutions. When these metals are cast in different combinations, for example,

	Copper	Tin	Zinc	Lead
Standard bronze	88	10	2	..
Standard red brass	85	5	5	5
Yellow brass	59	3	38	..

also alloys with copper or nickel base plus zinc, with small percentages of iron and silicon, etc., it has been observed that within 24 hours they are readily attacked in the same strengths of acid solutions mentioned.

As another example, two samples, designated as A and B, of approximately the same weight were obtained from an acid-resisting alloy and were so machined that sample A exposed more of the outside or closer-grained part, and sample B more of the inner or coarser grain. They were then forwarded to the chemist of a mine in West Virginia, so as to enable him to test them out in the running mine water, which test is believed to be much nearer to the actual working conditions of a pump than laboratory tests. The results obtained were as follows:

	Sample A	Sample B
Loss in 14 days, per cent	1.78	3.68
Loss in 28 days, per cent	2.35	4.63

In other words, the loss from the coarser-grained sample was approximately twice that from the one of finer grain.

The company has succeeded in producing an alloy of a very dense structure, which is practically immune to the action of sulphuric acid of different strengths and temperatures; this metal has also been tested in the worst kind of mine water, with very gratifying results. Tests were made on this metal, designated as M-3, similar to the tests on the samples A and B previously mentioned, covering periods of 14 and 28 days. The loss in 14 days was 0.05 per cent, and in 28 days, 0.13 per cent. The tests are being continued for 90 days or a longer period, as long as interesting results are obtained. The alloy complies with the four major conditions mentioned earlier, with one exception. At the present time it has not been found possible to give this metal the strength necessary to withstand the ordinary wear and tear of mine pumps. Consequently it is not as yet a good commercial proposition.

In dealing with synthetic alloys a great deal of trouble has been encountered with segregation, especially in the larger castings. An example of such segregation would be, for instance, in an alloy of copper, nickel and zinc (placing it in the german silver group), which, if the casting has any free zinc segregation, is immediately attacked by sulphuric acid and in a short time becomes useless.

In dealing with metals used in mine pumps, it is found that the laboratory tests and the actual working conditions are vastly different. In the first instance there is but one destructive agency to be dealt with, namely, corrosion, while in the actual workings of a mine pump there are two, corrosion and erosion, and sometimes electrolysis. Therefore laboratory tests have a tendency to give results which cannot always be relied upon. For instance, two samples of acid-resisting metal were cut from the same piece in the same manner. Laboratory tests covered the immersion of one of these samples in the mine water received from a mine in West Virginia, the loss over a period of 90 days being 1.200 per cent. The second sample was forwarded to the mine and placed in the running water for a period of 14 days, with a resultant loss of 1.78 per cent.

Again, in the pumps made of the company's acid-resisting metal known under the trade name of Meco, it is found from experience that in pumping sulphuric acid of various strengths and temperatures the conditions are not as severe as when pumping mine water.

Tests on the Rate of Corrosion of Various Metals and Alloys

A series of tests on the rate of corrosion for a definite period of time, by weight, at room temperature, in concentrated sulphuric acid (sp. gr. 1.84), and a 10 per cent solution of the same acid (sp. gr. 1.07), on various metals and alloys, gave the results presented in Table 1. The samples were of approximately the same size and weight, about 15 grams, and the acid was renewed after every 100 hours' run.

TABLE 1 TESTS ON THE CORROSION OF VARIOUS METALS AND ALLOYS IMMERSED IN DILUTE AND CONCENTRATED SULPHURIC ACID

500 Hours in Sulphuric Acid—10 per cent Solution:

Metal or alloy	Base	% Loss	Condition of piece	Remarks
New Meco	Copper	6.851	Copper vigorously attacked	Cast, fairly dense
Meco	Copper	3.551	Copper and nickel vigorously attacked	Cast under pressure
Monel	Nickel	3.066	Copper and nickel vigorously attacked	Rolled, very fine
M-3	Lead	0.606	Copper and tin slightly attacked	Cast, medium grain
Lead	Lead	0.0317	Very slightly attacked	Cast, very dense
Lead (90%) and Antimony (10%)	Lead	0.019	Very slightly attacked	Cast
Tobin bronze	Copper	1.447	Moderately attacked	Rolled
88–10–2	Copper	2.980	Vigorously attacked	Cast, medium grain
M–3–1	Lead	0.506	Slightly attacked	Cast

500 Hours in Concentrated Sulphuric Acid:

Metal	Base	% Loss	Condition of piece
C-New Meco	Copper	0.580	Slightly attacked
O-Meco	Copper	0.994	Mildly attacked
M-3	Lead	1.584	Moderately attacked
F-Monel	Nickel	1.027	Moderately attacked
Lead	Lead	1.104	Moderately attacked
Lead and Antimony	Lead	1.105	Moderately attacked
Tobin bronze	Copper	4.834	Vigorously attacked
88–10–2	Copper	4.612	Vigorously attacked
M–3–1	Lead	1.467	Moderately attacked

These figures clearly demonstrate that lead-base alloys are more resistant to dilute sulphuric-acid solutions than copper- and nickel-base alloys. The nickel-base alloy (monel) and the copper-base alloy with nickel (Meco) are more resistant to the concentrated acid than to the diluted form. Copper-base alloys with tin and zinc (88–10–2) also copper-base alloys with zinc (Tobin bronze) are readily attacked in both solutions.

An example of the very detrimental effect of a mine water on various metals and alloys follows, with the analysis of the mine water showing a trifle less than 479 grains of mineral matter and a little less than 92 grains of free acid (as sulphuric) per gallon. When placed in a ditch of this running water for varying periods the losses were as follows:

	Period of immersion, days	Loss per cent
Bronze (acid-resisting)	42	1.38
Ordinary brass	13	2.04
Monel metal	27	3.73
Bronze (acid-resisting)	14	3.89
Cast iron (acid-resisting)	7	7.45
Cast iron (acid-resisting)	14	11.26

Numerous tests have also been made with different metals and alloys to note their acid-resisting properties in solutions made up

(*Continued on page 621*)

Tests on Welded Cylinders

By E. A. FESSENDEN,[1] TROY, N. Y., AND L. J. BRADFORD,[2] STATE COLLEGE, PA.

In order to compare the methods of constructing cylinders for handling anhydrous ammonia, four types of construction were tested, namely: Flange-steel shell, acetylene-welded longitudinal seam, concave heads forge welded to shell; seamless-pipe shell, convex head acetylene welded to shell; seamless-pipe shell, concave heads forge welded to shell; and flange-steel shell, acetylene-welded longitudinal seam, convex heads acetylene welded to shell. This paper describes the method of conducting the tests, presents the data obtained, and discusses the results.

The authors conclude that vessels having forge-welded heads are the least reliable and that burnt steel is often present in the weld. Also that the principal defects in acetylene welds are the coarse granular structure and the occasional porous spots and pinholes that develop with high pressures and the poor adhesion of the welding material to the original plate. Reasonable practical remedies for these defects are given.

AT THE request of a large machinery-manufacturing company, the following impartial tests on the five welded containers described below, were conducted by the authors.

The tests were carried on without interference or suggestions from outside sources, and the idea uppermost was that the results should indicate the relative merits of the containers under consideration.

The object of the tests was to compare several different methods of constructing the cylinders for handling anhydrous ammonia in refrigerating-plant practice. The cylinders tested involved the following four types of construction:

a Flange-steel shell, acetylene-welded longitudinal seam, concave heads forge welded to shell

b Seamless-pipe shell, convex heads acetylene welded to shell

c Seamless-pipe shell, concave heads forge welded to shell

d Flange-steel shell, acetylene-welded longitudinal seam, convex heads acetylene welded to shell.

All of the dished cylinder heads were hot pressed from flat disks in a large press or flanging machine manufactured by R. D. Wood & Co., Philadelphia, Pa.

Methods Used in Making Welds

In making the forge-welded heads the shell and head were heated to the welding heat in an ordinary forge fire and the welds were made by hand hammers and sledges. Fig. 1 shows the construction of one of these forge-welded heads.

The following description of the method of making a cylinder of seamless pipe will indicate the methods used for all the acetylene-welded cylinders.

A piece of seamless pipe of the required length to make the shell is cut off by an acetylene torch. The ends of this shell piece are not scarfed, the heads being welded directly to the ends as they are left by the cutting torch. The head is made of flange steel pressed into the dished shape, convex outward, commonly used for cylindrical vessels made to withstand internal pressure. The edge of the flange of the head is turned so as to make a square f e and then the outer corner is beveled off to form a scarf. The shell and the head are then placed close together but not touching, the distance between the end of the shell as left by the cutting torch and the nearest edge of the scarf on the head being about $^1/_8$ in. Fig. 2 is a detail of the method of scarfing for making the joint and Fig. 3 shows a head in the process of welding.

When the torch is applied the metal of the shell and the head are first heated until they melt into a viscous fluid which flows down and closes up the gap between the two edges. Most of this material is taken from the shell, so that this melting-down process is practically equivalent to scarfing the edge previously left by the cutting torch. The metal from the welding wire is introduced not by melting it off the end of the wire and dropping it into the crevice between the parts to be welded as in a soldering operation, but by stirring the end of the welding wire in a little pool of molten material formed from the metal of the shell and head. Welds made in this manner are often called "ripple welds." Only very rarely was the hottest part of the torch flame allowed to play upon the welding wire, material from the wire being almost invariably introduced into the weld by the puddling process just outlined.

For longitudinal seams the welding operation was carried on in the same manner as that described for girth seams, the process being as follows: The plate used to form the cylindrical shell is rolled into shape so that the edges of the longitudinal joint nearly touch, the shell being laid longitudinally with the joint uppermost. The seam is then started at one end and welded for a distance of about 2 in. For the remainder of the seam the edges are spread apart and held in position by a jack. The amount of spreading is about $^1/_2$ in. to $^3/_4$ in. per ft. length of seam and thin shells are spread the most. As the welding progresses toward the end where the jack is placed, the strain on the edges is gradually reduced so as to allow the edges to be welded to approach each other. This device is used to eliminate as far as possible temperature stresses due to a high temperature of the welded seam.

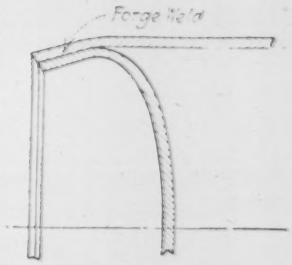

FIG. 1 CONSTRUCTION OF FORGE-WELDED HEAD

Method of Conducting Tests

The cylinder under test was blocked up on a light truck and filled with water through openings left for the purpose. The diameter was then carefully measured at five points equally spaced along the length of the cylinder. In the cylinders made of seamless pipe these diameters were measured only horizontally as the cylinder lay in the testing rack, but in the cylinders rolled out of flange steel vertical diameters were also measured at all of the five points where the supporting blocking did not interfere with the use of calipers. Careful measurements were also made to determine the contour of each cylinder head.

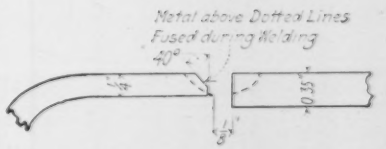

FIG. 2 SCARFING METHOD FOR MAKING THE JOINT

The cylinder was then connected to a hand-operated hydraulic-testing pump, with a new and calibrated hydraulic-pressure gage in the connecting pipe line. The pressure was then gradually increased, stopping occasionally to observe carefully the condition of the cylinder and to repeat the measurements indicated above whenever it seemed desirable to record changes in the shape of the cylinder. This was continued until the cylinder failed to such an extent that the defects which developed caused leaks which made it impossible to operate the pump rapidly enough to cause further increase in the pressure.

When a cylinder had failed a number of samples were marked on the cylinder and ordered to be cut out for microscopic, metallurgical and physical tests. These samples were later shipped to the authors at State College, Pa., where they were properly prepared and examined as to their physical properties and microscopic structure. The tension tests were made by Prof. Thomas S. Patterson (Assoc. Mem. Am.Soc.M.E.), of the Department of Mechanics and Materials of Construction in the School of Engineering at The Pennsylvania State College. The microscopic and metallurgical examination was made by Prof. O. A. Knight (Mem. Am. Inst. Mining and Metallurgical Engineers, American Electrochemical Society and American Society for Steel Treating), of the Department of Metallurgy in the School of Mines of the Pennsylvania State College,

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whose report is published in an appendix to the complete paper.

TEST RESULTS ON CYLINDER NO. 1

The construction of cylinder No. 1 is shown in Fig. 4. The shell was made of flange steel, 1/4 in. thick, with the longitudinal seam acetylene welded. The heads were pressed from 1/4-in. flange-steel plate to a dished shape, and with a straight cylindrical flange about 2 1/2 in. long. The heads were inserted into the end of the shell with the convex side inward and the edge of the flange of the head forge welded to the shell, the depth of the

FIG. 3 PARTLY COMPLETED ACETYLENE WELD

weld being from 1 in. to 1 1/2 in. in the case of this cylinder. The welded ends were then crimped over to reinforce the weld as shown previously in Fig. 1.

The cylinder set up for testing is shown in Fig. 5. The outside diameters, measured before testing on the lines between the numbered sections, were as follows:

Between sections.....	1–2	2–3	3–4	4–5	5–6
Horizontal diameter, in...	12.17	12.28	12.34	12.34	12.28
Vertical diameter, in.....	...	12.41	12.38	...	12.44

The following observations were made during the test at the pressure indicated:

500 lb. per sq. in. The concave head of section 1 began to reverse curvature, becoming completely convex shortly afterward.

700 lb. per sq. in. The concave head of section 6 began to reverse curvature, and very rapidly became completely convex.

950 lb. per sq. in. Leakage began through forge weld at head of section 1.

1350 lb. per sq. in. Forge weld at head of section 6 began to leak slightly.

1450 lb. per sq. in. Very bad leak through weld at head of section 6. Complete failure.

Fig. 6 shows the head of section 6 after complete failure had occurred at 1450 lb. per sq. in. internal pressure. The defective spot in the forge weld which caused final failure is on the upper left-hand quadrant.

This illustration also shows very clearly the final shape of the head after complete reversal of curvature had taken place. Accompanying the deformation of the heads the ends of the shell which were crimped over to reinforce the weld were straightened out by the bending stress on the flange of the head. As a result, after the head had completely reversed its curvature it was found that the crimping had nearly all disappeared. This obviously introduced a circumferential tensile stress upon the weld that probably contributed to the final failure. The spreading of the crimped end can be seen by a comparison of Figs. 5 and 6 and is particularly noticeable along the upper side of the shell.

During the test measurements were taken to give the contours of the heads in order to show their progressive deformation under increasing pressures. These readings were later plotted.

The factor of safety may be considered to be any one of a number of values, depending upon what is considered to be the point of failure of the cylinder. The cylinders were similar to those used by the company for holding anhydrous ammonia at an internal working pressure of 185 lb. per sq. in. gage. Using this as a basis the authors find the following factors of safety:

a If failure is considered as occurring at the first indication of deformation of the concave heads, the factor of safety is 2.70.

b If the vessel be considered to have failed as soon as the first leakage occurred, the factor of safety is 5.13.

c On the basis of the maximum pressure attained in the test with complete failure of the forge weld, the factor of safety is 7.85.

At the maximum pressure attained in the test the stress in the material forming the shell was 34,400 lb. per sq. in. of cross-section, computed on the basis of the original mean diameter of the shell. If the effective thickness of the weld is considered to be the same as that of the shell material, this value is also the stress safely withstood by the acetylene-welded longitudinal seam. On the samples cut out of this cylinder for physical tests the actual mean thickness of the weld itself was carefully measured, and for welds made in 1/4-in. plate the average thickness was found to be 0.350 in. Hence the actual stress withstood by the acetylene-welded seam during the test without any sign of failure was 24,500 lb. per sq. in. This amounts to 8590 lb. per linear inch of acetylene-welded seam. The stress which caused final failure of the forge-welded seam was one-half of this or 4295 lb. per linear inch of seam.

Four samples were cut from one of the circular flange-steel blanks such as are used for making the dished heads. The results obtained when tested for tensile strength are presented in Table 1.

TABLE 1 TENSILE-STRENGTH TEST OF CYLINDER NO. 1 SPECIMENS

Sample	Dimensions, in.	Area, sq. in.	Load, lb.		Tensile strength, lb. per sq. in.	
			Yield point	Ultimate	Yield point	Ultimate
A	0.243×2.00	0.486	17,000	24,500	35,000	50,400
B	0.242×2.01	0.486	17,580	25,100	36,200	51,750
C	0.241×2.01	0.484	17,690	25,180	36,500	52,000
D	0.242×2.025	0.491	16,950	25,520	34,500	52,000
	Average				35,425	51,538

The ultimate strength of the plate tested was thus somewhat below that specified for flange steel as set forth in the Boiler Code of The American Society of Mechanical Engineers (p. 11, Par. 28, edition of 1918), where the requirement is given as 55,000 to 65,000 lb. per sq. in. The elastic limit, or yield point, is above the requirement which states that at the yield point the stress shall have a minimum value of one-half the ultimate tensile strength, i.e., 27,500 to 32,500 lb. per sq. in. The fractures were typical

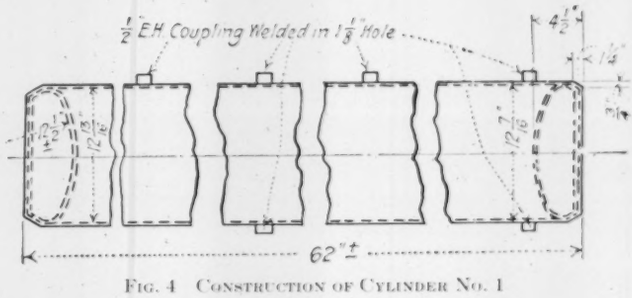

FIG. 4 CONSTRUCTION OF CYLINDER NO. 1

flange-steel fractures showing a very fine grain. The amount of elongation and the reduction in area were not determined.

Three samples containing sections of the acetylene-welded longitudinal seam were cut out of the cylinder and subjected to tension tests. Professor Patterson's report upon these specimens gave the results presented in Table 2.

The average ultimate strength was slightly above the value of 28,500 lb. per sq. in. specified by the Boiler Code of The American Society of Mechanical Engineers, for properly made forge welds (p. 45, Par. 186, edition of 1918). The average ultimate strength per linear inch of acetylene-welded seam was 10,097 lb.

The fractures occurred in every case through the body of the weld

TABLE 2 TENSION TEST OF CYLINDER NO. 1 SPECIMENS

Sample	Dimensions at weld, in.	Area at weld, sq. in.	Ultimate load, lb.	Tensile strength, lb. per sq. in.
E	0.362×1.452	0.526	13,800	26,250
F	0.335×1.504	0.504	15,820	32,000
G	0.354×1.734	0.614	17,810	29,000
	Average			29,083

itself, practically at the center line of the seam. In every case the fracture started with a crack which grew larger as the tension was increased. The final fracture did not occur suddenly and with a strong pronounced snap, as would be the case with a good flange steel, but was slow and gradual, as might be expected from a loosely knit, coarse, granular material, and was very similar to that obtained when a piece of putty is pulled in two. The elongation was not measured, but if any occurred it was very slight indeed. There was no apparent reduction of area. The fractured surfaces exhibited a very coarse granular structure quite similar to cast iron, with occasional brighter crystalline areas and flaws. There was evidence of poor adhesion between the metal of the shell and the welding material, especially along the bottom edge of the seam below the bevel of the scarf.

In Fig. 6 the horizontal lines chalked on the shell and the radial lines on the head indicate approximately the boundaries of sections later cut out for microscopic and metallurgical examination. The section containing the leak in the forge weld which caused final failure was cut into small pieces for examination and designated as specimens *PO*, *PI*, *PE* and *PZ*. These samples were cut in the order given reading from left to right in Fig. 6, *PE* being the small sample containing the crack which caused final failure. (See Appendix to complete paper for examination report.)

CYLINDER NO. 2

The construction of cylinder No. 2 is shown in Fig. 7. The shell was made of seamless-steel pipe approximately 0.34 in. in thickness. The heads were of dished form, with a straight cylindrical flange of the same external diameter as the shell and about 1½ in. long. The heads were welded to the shell by the acetylene torch with the convex face outward.

The cylinder was set up for testing like cylinder No. 1 and marked off into sections. Outside diameters (in inches) were measured only in the horizontal plane, before and during the test, as follows:

Between sections	1-2	2-3	3-4	4-5	5-6
Before test	12.65	12.73	12.78	12.78	12.73
At 2550 lb. per sq. in.	13.08	13.05	13.05	13.05	13.05

FIG. 5 CYLINDER NO. 1 READY FOR TESTING

The following observations were made during the test at the pressures indicated:

600 lb. per sq. in. Faint cracking sounds heard at end of section 6.

1200 lb. per sq. in. Scale cracks were observed in the forge scale on each head at the sharp bend where the flange is formed on the head. These scale cracks are shown very clearly in Fig. 8, and indicate that sufficient deformation of the convex head to crack the scale had occurred.

2000 lb. per sq. in. A very slight leak through the acetylene-welded circumferential seam joining the cylinder head to the end of section 1. This leakage was so slight, more in the nature of barely perceptible seepage, that during the entire test not more than three or four drops of water escaped.

2550 lb. per sq. in. A small leak occurred where a ½-in. extra heavy pipe coupling was acetylene welded to the shell in section 5 of the cylinder.

2600 lb. per sq. in. The leak observed at 2550 lb. per sq. in. where the coupling acetylene welded to the shell in section 5 became so large as to constitute complete failure.

The progressive approach toward the truly hemispherical head was quite apparent.

The factor of safety, computed on the same basis as for cylinder No. 1, may be taken as one of the following figures:

a If failure is considered as occurring when the first indication of deformation was observed (the cracking sounds heard near the head of section 6), the factor of safety is 3.24.

b If the vessel is considered to have failed at the first apparent leakage, the factor of safety is 10.81.

c On the basis of the maximum internal pressure reached, the factor of safety is 14.06.

Assuming the effective thickness of the weld to be the same as that of the shell material, i.e., 0.34 in., the stress in the circumferential seam at a pressure of 2000 lb. per sq. in., when the first very

FIG. 6 HEAD OF CYLINDER NO. 1 AFTER TEST, SHOWING FORGE WELD WHICH FAILED. POINT OF FAILURE MARKED BY ARROW

slight leakage was observed, was 17,700 lb. per sq. in. on the basis of the original mean diameter of the shell. This amounts to 6020 lb. per linear inch. On the same basis and the maximum pressure reached during the test, the stress on the seam was 23,000 lb. per sq. in. or 7830 lb. per linear inch of seam.

Two test pieces containing circumferential-seam samples were

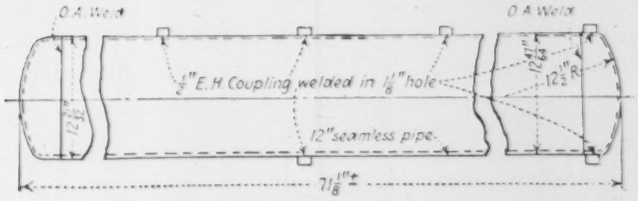

FIG. 7 CONSTRUCTION OF CYLINDER NO. 2

cut out for tension tests. Careful measurements of the actual mean thickness of the seam gave an average value of 0.442 in. Using this figure instead of the nominal thickness of 0.34 in., the stresses withstood by the seam during the test were as follows:

At the first slight seepage	13,620 lb. per sq. in. of seam
For the maximum pressure	17,690 lb. per sq. in. of seam

A number of samples were cut from this cylinder for tension tests. They were located as follows:

Sample H was cut from the head of section 1. This sample may be located by reference to Fig. 8. It contained the letters GC shown at the top of the head. The very small seepage leak was also in this sample.

Sample I was similar to sample H and was cut out of the head at the end of section 6.

Sample J was a circumferential section cut out of the shell. The location was about 5 in. to the right of the coupling that caused final failure.

FIG. 8 HEAD OF CYLINDER NO. 2, SHOWING SCALE CRACKS INDICATING DISTORTION

Sample K was a longitudinal sample cut from the shell at a point about 6 in. away from the coupling that caused final failure and on the back side of the cylinder.

Professor Patterson's results for the tension tests of these samples are given in Table 3. For the shell material the elastic limit and the ultimate strength were each above the value specified for boiler-plate steel in the Boiler Code of The American Society of Mechanical Engineers. The elongation and reduction in area were not measured but were considerably less in amount than were obtained for the flange steel used for the heads in the tests described in connection with cylinder No. 1. The fractures were fine-grained.

TABLE 3 TENSION TEST OF CYLINDER NO. 2 SPECIMENS

Sample	Dimensions, in.	Area, sq. in	Load, lb. Yield point	Load, lb. Ultimate	Tensile strength, lb. per sq. in. Yield point	Tensile strength, lb. per sq. in. Ultimate
H	0.46 ×2.38	1.094	...	28,200	...	25,820
I	0.424×2.05	0.87	...	25,850	...	29,750
	Average of acetylene-welded seams					27,785
J	0.345×1.55	0.535	27,000	35,620	50,500	66,700
K	0.341×1.51	0.515	24,000	33,310	46,700	64,700
	Average of shell material					65,700

The average ultimate strength of the acetylene-welded seams was slightly below that specified by the Boiler Code for good forge-welded joints. On the basis of the average ultimate strength of the acetylene-welded seam, it would require a load of 12,010 lb. per linear inch of seam to detach the head from the shell. The fractures of the acetylene-welded joints exhibited in general the same characteristics as were described for the acetylene-welded joints of cylinder No. 1, except that in sample H the welding material pulled away from the head, opening up the spot where the slight leakage occurred. At this point the color was somewhat darker than for the remainder of the fracture. All the indications thus point to poor adhesion at the junction of the head and the welding material, probably due to oxidation.

CYLINDER NO. 3

The shell was made of the same kind of seamless pipe as that used in the shell of cylinder No. 2, but about 6 ft. long. The heads were similar to those used in cylinder No. 1 and were forge welded to the shell in the same manner.

The ends of the shell were crimped over to reinforce the forge weld, and like the other two cylinders, the shell was marked off into sections. The outside diameters (in inches) of the shell measured in the horizontal plane before and during the test were:

Between sections	1–2	2–3	3–4	4–5	5–6
Before test	12.64	12.76	12.81	12.81	12.75
At 550 lb. per sq. in.	12.66	12.76	12.83	12.81	12.75
At 1300 lb. per sq. in.	12.70	12.76	12.81	12.80	12.75

The following observations were made during the test at the pressures indicated:

200 lb. per sq. in. The concave head in the end of section 1 began to show tendency to reversal of curvature, distortion beginning at a place where the head had been somewhat flattened (presumably) during the process of forge welding to the shell.

550 lb. per sq. in. The concave head in the end of section 1 completely reversed in curvature.

1000 lb. per sq. in. The concave head in the end of section 6 became convex. The distortion of the head in the end of section 1 had increased markedly.

1300 lb. per sq. in. The head at section 1 was stretching rapidly and slight leaks appeared through the forge-welded joint at both heads.

1380 lb. per sq. in. Complete failure resulted from excessive leakage through the forge weld joining the head to the shell at the end of section 1. The leakage was so great that it was not possible to increase the pressure further with the pump available.

During the test, measurements were taken to show the progressive distortion of the cylinder heads. The final shape of the head of section 1 is shown in Fig. 9, and the excessive distortion in the upper left-hand quadrant coincides in position with the flattened area previously mentioned as being present in the head before the test was started and presumably caused accidentally during the forging of the joint. The final failure of the welded joint occurred in this same quadrant at a point about 30 deg. above the horizontal diameter and on a radius through the region of most excessive distortion. This is the result that would be expected, since the greatest peeling action on the weld would occur where the distortion is the maximum.

No samples were taken from this cylinder for further tests. The failure was quite similar to that of cylinder No. 1, and there was no reason for believing that further examination of the forge weld which failed would yield results differing materially from those found for the joint in the first cylinder. There was no open crack similar to that in cylinder No. 1 but the welded joint very clearly opened up to the outer edge of the joint. The opening could be distinguished easily by the naked eye.

The factor of safety, computed on the same basis as for cylinder No. 1, may be taken as one of the following figures:

a If failure is considered as occurring when the first sign of deformation of the head of section 1 was observed, the factor of safety is 1.08.

b If the cylinder is considered to have failed at the first apparent leakage, the factor of safety is 7.03.

c On the basis of the maximum internal pressure reached during the test, the factor of safety is 7.46.

The stress withstood by the forge-welded joint was 3920 lb. per linear inch of joint on the basis of the first apparent leakage, and 4040 lb. per linear inch when the leakage became so great as to constitute complete failure.

CYLINDER NO. 4

The shell was made of $^1/_4$-in. flange steel rolled to an average outside diameter of approximately $12^{11}/_{16}$ in. and with the longitudinal seam acetylene welded. The shell construction was thus practically

FIG. 9 FINAL SHAPE OF HEAD OF CYLINDER NO. 3, SHOWING FORGE WELD WHICH FAILED

identical with that of cylinder No. 1. The heads were pressed out of 1/4-in. flange steel, and of the same construction as those of cylinder No. 2, being acetylene welded to the shell with the convex face outward.

Like the others, this cylinder was marked off into sections and the outside diameters (in inches) of the shell measured before and during the test were as follows:

Between sections	1–2	2–3	3–4	4–5	5–6
Horizonal, before test	12.19	12.38	12.41	12.41	12.31
Vertical, before test	12.55	12.52	12.44	...	12.39
Horizontal, 800 lb. per sq. in.	...	...	12.44	...	...
Vertical, 800 lb. per sq. in.	...	...	12.44	...	...

The following observations were made during the test at the pressures indicated:

1000 lb. per sq. in. Scale began to crack at bend of flange in head at end of section 1.

1200 lb. per sq. in. Distortion of head at end of section 1 continued; head at end of section 6 began to show distortion.

1400 lb. per sq. in. Considerable distortion apparent in both heads. The head at the end of section 1 showe ' an increase in diameter in the part flanged over into cylindr al shape as indicated in Fig. 10.

1700 lb. per sq. in. Complete failure occurred suddenly by tearing the acetylene-welded longitudinal seam. Failure apparently began by the material which had been added from the welding wire tearing away from the plate for a distance of about 3 in. Then the tear extended in both directions through the body of the weld itself until the total length of the tear was about 16 in. The broken surface exhibited a very coarse granular structure. Fig. 11 shows the final fracture. The part which is thought to have failed first is below and to the right of figure 2 in the photograph. Where the tear left the weld and extended into the shell material at the left-hand end is also shown.

The factor of safety, computed on the same basis as for cylinder No. 1, may be taken as one of the following figures:

a On the basis of the first noticeable distortion of the cylinder head, the factor of safety is 5.41.

b On the basis of final complete failure, the factor of safety is 9.18.

For the pressure at which the acetylene-welded longitudinal seam failed and assuming the effective thickness of the weld to be the same as that of the shell material, the stress in the seam was 40,500 lb. per sq. in. Measurements on samples of the weld cut out for tests showed the average actual thickness of the weld to be 0.358 in., so that the actual ultimate strength of

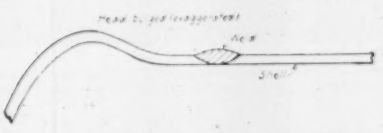

FIG. 10 DISTORTION OF HEAD AT THE END OF SECTION 1 OF CYLINDER NO. 4

FIG. 11 FINAL FAILURE OF ACETYLENE-WELDED LONGITUDINAL SEAM OF CYLINDER NO. 4

the weld was 28,300 lb. per sq. in., or 10,140 lb. per linear inch of welded seam.

Three samples were cut from the longitudinal seam at a point well removed from the section which failed and subjected to tension tests by Professor Patterson. The results are given in Table 4.

TABLE 4 TENSION TEST OF CYLINDER NO. 4 SPECIMENS

Sample	Dimensions at weld, in.	Area at weld, sq. in.	Ultimate load, lb.	Tensile strength, lb. per sq. in.
L	0.336×1.919	0.645	22,710	35,200
M	0.373×1.670	0.623	17,590	28,200
N	0.365×1.924	0.693	18,170	26,200
	Average			29,870

The average ultimate strength is above the requirement of the Boiler Code of The American Society of Mechanical Engineers for

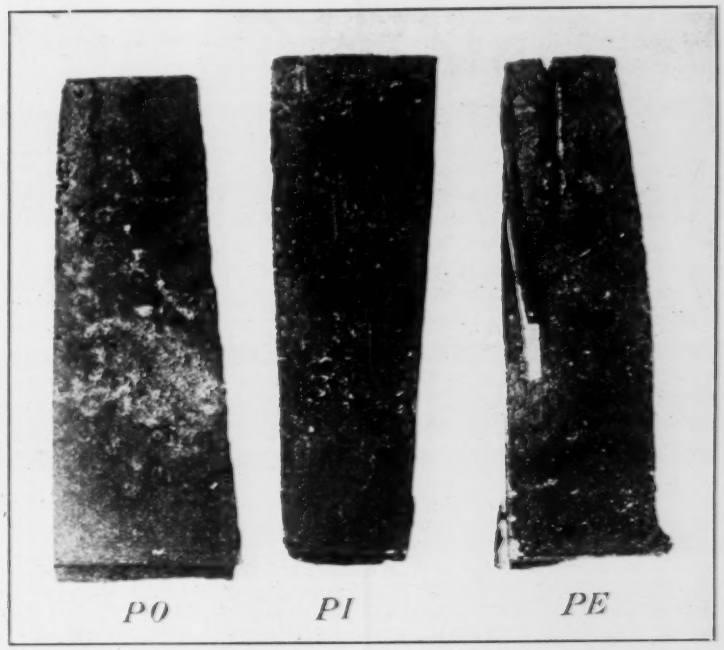

FIG. 12 CRACKS IN SPECIMENS OF CYLINDER NO. 1 REVEALED BY ETCHING AND THE CRACK IN SPECIMEN *PE* WHICH PROBABLY CAUSED FAILURE; MAGNIFICATION 1.5

good forge welds. The fractures exhibited the same characteristics as were described for the test pieces of cylinder No. 1, except that one specimen, sample L, failed by pulling the welded-in material away from the shell material instead of tearing through the center of the weld. The other two specimens showed a discolored region in the fracture that indicated the same poor knitting together at the bottom of the scarf already commented upon in the description of the fractures of weld specimens in connection with cylinder No. 1.

The average ultimate strength of the acetylene-welded seam per linear inch of seam computed from Professor Patterson's tests, is 10,770 lb.

CYLINDER NO. 5

The shell of this cylinder was made of seamless pipe 12¾ in. in outside diameter, with pressed dished heads acetylene welded to the shell with the convex face outward, the construction being the same as that of cylinder No. 2, except that the finished cylinder was only about 3 ft. long instead of 6 ft.

A short time before finishing the tests on the first four cylinders already described, it was decided to test an additional cylinder taken out of stock. Therefore, cylinder No. 5 was chosen from a pile in the welding shop. One of the welded girth seams did not appear to be as good as those in some of the other cylinders, a second course of welding apparently having been run around the seam.

As this cylinder was tested simply as a check to compare the workmanship on stock cylinders with those submitted for test, it was not considered necessary to take detailed observations during the test. The cylinder behaved in practically the same manner as cylinder No. 2, except that no leakage through the circumferential seams was observed. Final failure occurred at a pressure of 1900 lb. per sq. in. by serious leakage through an acetylene weld securing a pipe coupling in one of the heads. The scale cracks along the bend of the flange of the head and the tendency of the head to assume a hemispherical shape were also noticeable.

On the basis of final failure and assuming that the working pressure for which the cylinder was designed was 185 lb. per sq. in. as in the other cylinders tested, the factor of safety is 10.28.

Using the same initial diameter as in cylinder No. 2 and assuming that the effective thickness of the acetylene-welded circumferential seam is the same as that of the shell material, this seam safely withstood a stress of 16,820 lb. per sq. in. of cross-section without any sign of leakage or distress. If the actual thickness of the weld is taken to be 0.442 in. as was found on carefully measured

specimens of similar welds in cylinder No. 2, the stress safely withstood was 12,930 lb. per sq. in. The stress per linear inch of seam safely withstood was 5715 lb., without any sign of leakage or distress of any kind.

SUMMARY

Table 5 summarizes the results of the tests. It is somewhat difficult to make a comparison between the acetylene-welded and the forge-welded seams on the basis of tensile strength, because the stress on the acetylene-welded seam is a direct tension while that on the forge-welded seam is shearing. Possibly the fairest comparison is the load which the seam will carry, expressed in pounds per linear inch of seam. Table 6 gives the strength of the several joints, using the results of the tests on the five cylinders as well as those obtained by Professor Patterson. Even this is not an entirely fair comparison, because some of the acetylene-welded seams are thicker than others. The average stresses per linear inch of seam are as follows:

	At first leakage through seam, lb.	At final failure of seam, lb.
Forge-welded seams	3365	4168
Acetylene-welded seams	8080	10754

DISCUSSION AND RECOMMENDATIONS

In considering the results here presented it must be borne in mind constantly that the object of the investigation was to compare different methods of constructing containers for anhydrous ammonia for use in refrigerating-plant practice. Even a comparatively small ammonia leak is sufficient to make the room in which it occurs untenable. If the leak occurs in a confined space where ventilation is poor, as, for example, on shipboard, the results may be quiet serious. In boiler practice absolute tightness is not nearly so important as adequate strength against serious rupture, but it should be emphasized that in the case of containers for anhydrous ammonia, *leakage constitutes failure*.

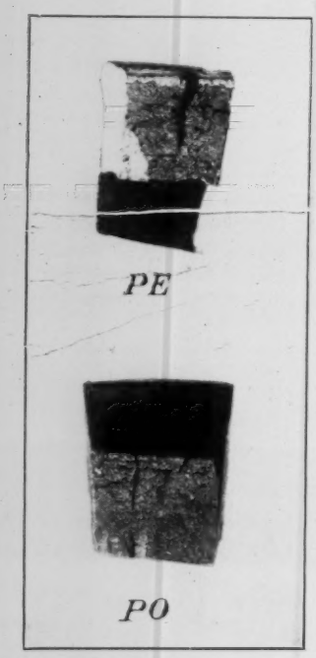

FIG. 13 END VIEWS OF SPECIMENS *PO* AND *PE*, SHOWING CRACKS EXTENDED DEEPLY INTO METAL; MAGNIFICATION 1.5

From all of the data secured by the tests themselves and also by subsequent investigation and analysis it appears that the vessels having forge-welded heads are the least reliable. The entire circumference of the weld is likely to have incipient cracks where the union between the flange of the head and the end of the shell is imperfect. If the common shape of dished head is used it obviously must be inserted in the shell with the concave side outward in order to make a forge weld. Under the action of heavy internal pressure the curvature of the heads is reversed and this sets up a tearing or peeling action which increases the incipient flaws in the weld and leakage follows. This result is still further aggravated by the opening out of the crimped ends due to the spreading action of the head during reversal and the consequent expansion of the material just at the weld. Furthermore, it is quite likely that the dished heads are more or less distorted during the forge-welding process. Surfaces that are subjected to pressure on the convex side are in a state of unstable equilibrium and even slight initial distortion will result in excessive distortion at much lower pressures than would be carried safely. This was shown in the case of cylinder No. 3, in which one head was somewhat flattened when received at the testing floor. This head began to reverse curvature at 200 lb. per sq. in. The initial distortion undoubtedly contributed to its low resistance.

TABLE 5 SUMMARY OF TEST RESULTS

Cylinder No.	1	2	3	4	5
Shell	Flange steel, longitudinal seam acetylene welded	Seamless pipe	Seamless	Flange steel, longitudinal seam acetylene welded	Seamless pipe
Heads	Forge welded to shell	Acetylene welded to shell	Forge welded to shell	Acetylene welded to shell	Acetylene welded to shell
Pressure at first leakage, lb. per sq. in.	950	2000	1300	1700	1900
Maximum pressure attained, lb. per sq. in.	1450	2600	1380	1700	1900
Cause of final failure	Leakage through forge weld	Leakage through acetylene-fitting weld	Leakage through forge weld	Rupture of acetylene-welded longitudinal seam	Leakage through acetylene-fitting weld
Factor of safety on first leakage	5.13	10.81	7.03	9.18	10.28
Factor of safety on final failure	7.85	14.06	7.46	9.18	10.28
Stress in longitudinal seam, lb. per sq. in.	34,400	....	....	40,500	....
Stress in circumferential seam, actual, at first leakage	....	13,620	....	28,300[1]	12,930
Same at final failure	....	17,690	....	28,300	12,930

[1] Caused final complete failure.

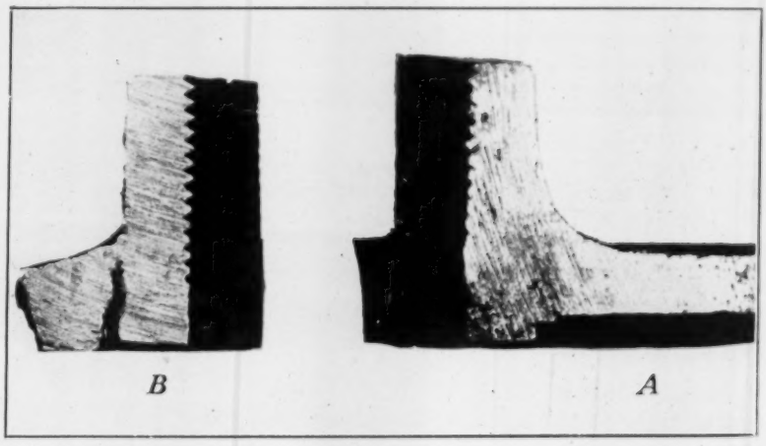

FIG. 14 TWO PIPE-COUPLING SPECIMENS. *B* IS THE NIPPLE OF CYLINDER NO. 2 WHICH LEAKED THROUGH THE WELD. *A* IS SOUND NIPPLE WELDING THAT DID NOT LEAK; MAGNIFICATION 1.5

In the forge-welded specimens examined microscopically, evidence of burnt steel was found in all cases. In general, burnt steel may be expected in forge welds because the burning temperature and the welding temperature for steel are quite close together. Some time must elapse, and hence some cooling takes place, between the instant the pieces are removed from the forge and the time at which the welding actually takes place. It is essential that the pieces be at the welding temperature at the time the blows are struck. The comparatively thin pieces in question lose heat rapidly and this leads to their requiring a higher forge temperature than pieces of more compact form, thus increasing the danger of burnt steel. Burnt steel and overheated steel are very weak and brittle as compared to steel not treated so. When burnt steel is forged, cracks like those in specimen *PE* (Fig. 12) are formed. This action renders leakage under pressure and consequent failure easy.

(*Continued on page 592*)

TABLE 6 STRESSES PER LINEAR INCH OF SEAMS

Cylinder No.	At first observed leakage through seam during test, lb.	At maximum pressure reached in test, lb.	At failure of joint by tension test, lb.
1 (forge-welded)	2810	4295	....
3 (forge-welded)	3920	4040	....
1 (acetylene-welded)	....	8590[1]	10097
2 (acetylene-welded)	6020	7830[1]	12010
4 (acetylene-welded)	10140	10140	10770
5 (acetylene-welded)	....	5715[1]	....

[1] Stresses marked thus are simply the highest stresses reached in tests where the final failure was due to other causes than failure of the seam in question.

Steam Utilization in a Modern Newsprint Mill

An Analysis of the Conditions Obtaining in a Modern Paper Mill Manufacturing Newsprint, Dealing with the Selection of a Prime Mover, Electric vs. Rope Drive for Paper Machines, the Drying of Paper, Ventilation Requirements, Etc.

By S. W. SLATER[1] AND J. E. A. WARNER,[2] CAPE MADELEINE, QUE., CANADA

THE purpose of this paper is to show the heat required in the manufacture of newsprint on a modern basis. It is, in general, a detailed study of the concrete conditions found to exist in a modern paper mill with which the authors have been associated. Other conditions found to exist in paper mills have been treated, however, with a view of showing their bearing upon the different subjects which are covered herein, and also to facilitate comparison by other mills whose installations are different from the one cited.

In general, the importance of heat conservation has not been appreciated in this industry and, in view of the national movement to conserve natural resources, all newsprint paper mills are in duty bound to study their own particular problem, so that their coal or fuel-oil requirements may be reduced to a minimum. It is hoped, therefore, that this paper may be of assistance to those who, no longer content with operating by rule of thumb, desire to analyze their heat load, in order to assist in conservation and to reduce the cost of manufacture.

A survey made as of January 1, 1922, shows that the United States and Canada have a combined daily output of about 8500 tons. The tonnage produced during the year 1921 was approximately 2,038,095 tons, and the value of this tonnage, at a representative figure of $100 a ton, would be $203,809,500.

On the basis of the familiar statement that "One ton of coal is required to produce one ton of paper," the newsprint industry has a yearly fuel demand equivalent to about 2,040,000 tons of coal. In the United States, it has been quoted as occupying sixth place in capital invested and value of product, while in horsepower installed it probably ranks fourth.

Description of Mill Investigated

The building housing the two paper machines is 288 ft. long by 88 ft. wide and has a total height of 45 ft. It is of standard brick and steel construction, with concrete floors and roof, the latter being waterproofed with tar and felt. The paper machines are carried on an operating floor which is 27 ft. from the roof. Underneath is a basement having a height of 18 ft. and its floor at grade level. Only the northeast side is exposed, other buildings adjoining the remaining side and ends. The openings in the exposed wall have a total area of 3000 sq. ft.

The greater part of the driving mechanism for this installation is located in the basement. The prime movers are steam turbines of the single-stage non-condensing type, direct-connected through flexible couplings to reduction gears, and have a rated capacity of 400 b.hp. at a speed of 2675 r.p.m. This gives a speed reduction of about 7 to 1. The turbo-gears in turn drive an English system of rope transmission, in which each section of the paper machine has its own jackshaft, carrying a cone pulley and sheaves.

By means of belts, power is transmitted from the cone pulleys on the jackshaft to the cone pulleys driving each section of the paper machine. The cone pulleys transmit through a friction clutch and herringbone gears to each of the sections. In the case of the drier sections further spur gears are used to drive from one drier to the next in the section.

The Paper Machines

The paper machines are of the Fourdrinier type, are 166 in. wide and have three presses. The drier sections consist of one fore drier, 24 in. in diameter by 162 in. face; 32 driers, 60 in. in diameter by 162 in. face; and two felt driers, one for each section, 48 in. by 162 in. All driers are of cast iron, bored on the inside, and turned and polished on the external surfaces. Each drier is equipped with a dipper, to remove the water of condensation. These machines are designed for a maximum speed of 700 ft. per min.

Newsprint consists of from 70 to 85 per cent of ground wood and the remainder sulphite pulp. After the mixture has been reduced to a consistency of about 1/2 per cent, it is caused to flow onto the wire of the paper machine in amounts carefully regulated so as to finally produce finished paper weighing 32 lb. per ream of 500 sheets, size 24 by 36 in.

The web is formed by the oscillating motion of the Fourdrinier section. Water is removed through the wire, assisted by the capillary attraction of the table rolls, which also act as carriers for the wire. The suction boxes remove a large quantity of water and assist in closing the sheet. The paper then passes between the couch rolls, which press out additional moisture.

In passing through the press sections the sheet is carried on woolen felts between weighted rolls, further reducing the moisture content.

The paper is then ready to enter the driers, where water is removed from the sheet by contact with steam-heated cylinders and is carried through same on canvas felts. The last drier is equipped for cold-water circulation, so as to dampen the sheet before it passes through the calender stack for ironing and polishing, prior to cutting to specified size and winding on cores.

Heat Required for Newsprint Manufacture

In order to show more clearly the heat required for newsprint manufacture, simultaneous tests were conducted on one of the previously mentioned machines to determine the heat demand for driving, drying and ventilating.

The data pertaining to the turbine test are given in Table 1. The steam supplied to the turbine was the same as that used by the driers. In other words, the turbine water rate balanced the drier heat demand and no auxiliary live steam was required.

TABLE 1 TURBINE TEST

Initial steam:	
Pressure, lb. per sq. in. abs.	160.7
Temperature, deg. fahr.	401.3
Total heat per lb., B.t.u.	1217.3
Exhaust steam used by driers:	
Pressure, lb. per sq. in. abs.	23.7
Temperature, deg. fahr.	248.1
Total heat per lb., B.t.u.	1164.7
Lb. steam per hour	16,822.60
Lb. steam per min.	280.37
B.t.u. per min. to turbine	14,747.30
Equivalent B.t.u. per b.hp. (as given by manufacturers)	44.17
B.hp. developed	334.00
Water rate, lb. per hp-hr.	50.37

In selecting a suitable prime mover the governing factor is the amount of steam required for drying the paper; consequently it does not follow that the engine or turbine having the lowest water rate is the most suitable.

The water rate of the prime mover, in conjunction with the initial steam pressure and quality, must also be such as to insure approximately dry exhaust steam, at drier pressure, as it is undesirable to have steam of a high moisture or superheat content entering the driers.

Fig. 1 has been prepared to show the effect of the water rate of the turbine upon the quality of the exhaust. It will be noted that for the rate existing at the time of the test the exhaust was superheated 11 deg. fahr., and that when 45 lb. were used per b.hp. per hour the exhaust steam would be dry-saturated.

In the past it has been very difficult to obtain data showing the horsepower requirements of paper machines, but with the advent of motor drives more information is becoming available. It is impossible to give a formula that will cover all installations, for the power requirements will vary with the type and mechanical design

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of the machine, the conditions under which it is operated and the efficiency of transmission. The following, however, is cited to show approximately the power demand of the variable-speed drive, and is based on a speed of 100 ft. per min. and 100 in. width:

1 Modern high-speed motor-driven machines, having four presses, forty 72-in. driers and operating at speeds varying between 700 and 1000 ft. per min.....25 to 30 hp.
2 Turbine-driven machines, rope-drive transmission, having three presses, thirty-two 60-in. driers, and operating at speeds of 550 to 700 ft. per min.....30 to 34 hp.
3 Engine-driven machines, Marshall drive, three presses, thirty-two 48-in. driers, and operating at speeds of from 350 to 600 ft. per min.....33 to 38 hp.

Electric Drives for Paper Machines

Much attention of late has been given to electric drives for paper machines, and in some recent installations the electric energy for driving is generated by a hydroelectric plant. The steam required for the driers is then obtained from high-pressure steam reduced through a pressure-reducing valve to a lower pressure, with consequent superheat; as will be shown later, however, superheat is not suitable for use in the driers.

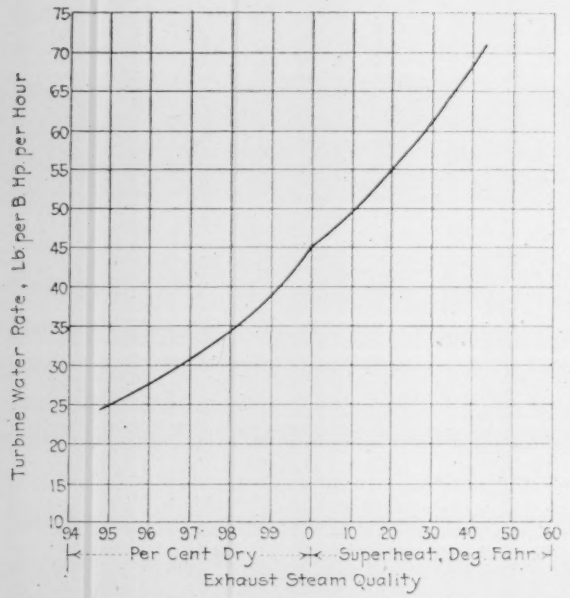

Fig. 1 Curve Showing Effect of Water Rate on Quality of Exhaust

Further, unless electrical power can be purchased at a cheap rate, it is not thought that such an installation is economical, and for the purpose of illustrating this point the following computations have been made to determine at what price electrical energy would have to be purchased to be the equivalent of steam assumed to cost $0.75 per 1000 lb.

Referring to Fig. 2, which is based on the test given in Table 1, straight line *A* (205.1 B.t.u.) represents the heat of the drier condensate, and line *C* (1217.3 B.t.u.) the total heat of one pound of steam under the conditions given. Curve *B* shows the relation between the water rate of the turbine and the heat contained in the exhaust available for drying.

AC (1012.2 B.t.u.) therefore represents the heat per pound of steam which would be available for drying if a pressure-reducing valve was used. *BC* (52.6 B.t.u.) represents the amount of heat abstracted from the initial steam in doing work in the turbine.

It will be seen that the quantity expressed by *BC* is small in comparison with that represented by *AB* (959.6 B.t.u.), and that the exhaust steam contains nearly as much heat as the initial steam.

From the preceding data and based on 7600 operating hours per year, to develop one brake horsepower-year, 20,136,000 B.t.u. are required. This is equivalent to 19,900 lb. of steam which, at an assumed cost of 75 cents per 1000 lb., makes the steam cost of a horsepower-year, approximately $15.

Assuming the efficiency of the electric drive to be 95 per cent and that of the drive described to be 75 per cent, the cost of purchased electrical power must not exceed $19 per hp. year.

This comparison does not take into consideration interest and depreciation on capital invested or the maintenance and operation costs; but as the initial cost of the electric drive is approximately two and one-half times that of a turbine rope-drive installation, it is thought, that if these costs were considered, the comparison would be favorable to the turbine rope drive.

The electrical installation, however, offers many advantages from the standpoint of operation, and with the development of high-speed machines will no doubt become the most acceptable type of drive. It is the opinion of the authors that the application of the motor drive will prove most economical when the necessary electrical power is developed by a turbo-generator, the exhaust from which would be utilized for drying the paper.

The bleeder or extraction type of turbine would have the advantage of greatest flexibility in that a minimum amount of steam would be wasted during periods of light loads, when practically no steam is required in the driers.

Drying Paper

In the drying of paper it is requisite that the moisture be removed gradually to prevent scorching and cockling of the sheet, and this requires a definite temperature gradient through the machine. It is also necessary that the temperature of the paper be kept within certain limits to produce a good, strong sheet.

The authors believe that the logical method to employ in these heat calculations is to base all figures on the pounds of moisture removed from the paper, instead of on the actual production. This is due to the fact that the moisture content is variable, depending upon the number and efficiency of the machine presses and the amount of moisture desired in the finished sheet.

The amount of moisture in the paper entering the drier section generally varies from 65 to 76 per cent, with an average of about 72 per cent. The amount of moisture in the finished sheet varies from 5 to 10 per cent, with an average of about 8 per cent. It is important that enough moisture remain in the finished sheet to insure proper finish and strength.

By the use of the following formula the number of pounds of moisture to be removed per pound of finished paper can be readily determined:

$$W = \frac{M_1 - M_0}{100 - M_1}$$

where W = pounds of moisture removed per pound of dried paper
M_1 = percentage of moisture in sheet entering drier section, and
M_0 = percentage of moisture in dried sheet.

It is important that as much moisture as possible be removed from the sheet before it enters the driers. It should be understood, however, that there are limitations to the amount of moisture that can be removed by mechanical means, namely, the possibility of crushing the delicate web of newsprint and the effect on the life of the press felts. Each mill, by considering the above in conjunction with the cost of steam, should determine the most efficient point of moisture removal.

In order to determine the economical life of machine clothing, in relation to steam cost for drying, a study of results obtained in several mills was made. This showed that the relation between life of felts and the percentage of moisture entering the driers followed a straight line, and that it is the combined felt-days of all the press felts which determines the moisture in the sheet entering the driers. This is a fortunate relation, in that the operating days of each of the three press felts is seldom the same at any one time.

Fig. 3 shows the relation between the combined felt-days of the three press felts and the average percentage of moisture leaving the presses for the period considered; this period being taken as one-third of the combined felt-days.

Table 2 is self-explanatory and shows the relation between combined felt-days of the three presses and the cost per day, in dollars, for steam and felts. The calculated costs do not take into account the labor and the loss of production due to changing clothing. Further, this study only applies for a particular period of fixed steam and machine-clothing costs, and should be revised as conditions change.

Some plants, thinking to economize, have tried to dispense with

drier felts. This procedure has not proved satisfactory, for the reason that intimate contact of the sheet with the drier surface is

TABLE 2 COST OF STEAM AND FELTS

Felt-days.	% Moisture entering driers at end of period	Avg. % moisture for period	Period in days (1) × 3	Moisture evap. per lb. of paper	Lb. steam per day $\frac{F. \& A. 212° F. (5) \times 5400 \times 24 \times 1.361}{970.4}$	Cost of steam per day. Dollars. $\frac{(6) \times 0.75}{1000}$	Cost of press clothing per day. Dollars	Cost of steam and felts per day. Dollars. (7) + (8)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
30	69.60	68.40	10.00	1.911	347,360	260.52	68.00	328.52
35	69.95	68.58	11.67	1.928	350,440	262.83	58.20	321.03
40	70.30	68.75	13.33	1.944	353,347	265.01	51.00	316.01
45	70.75	68.98	15.00	1.966	357,347	268.01	45.35	313.36
50	71.10	69.15	16.67	1.982	360,253	270.19	40.80	310.99
55	71.45	69.33	18.33	2.000	363,533	272.65	37.10	309.75
60	71.90	69.55	20.00	2.021	367,347	275.51	34.00	309.51
65	72.25	69.73	21.67	2.039	370,613	277.96	31.40	309.36
70	72.65	69.93	23.33	2.060	374,440	280.83	29.10	309.93
75	73.05	70.13	25.00	2.080	378,067	283.55	27.20	310.75
80	73.45	70.33	26.67	2.101	381,893	286.42	25.50	311.92
90	74.20	70.70	30.00	2.140	388,973	291.73	22.65	314.38
100	75.00	71.10	33.33	2.183	396,800	297.60	20.40	318.00
110	75.80	71.50	36.67	2.228	404,973	303.73	18.55	322.28
120	76.60	71.90	40.00	2.274	413,333	310.00	17.00	327.00

NOTE: 8 per cent moisture in dried paper. Steam cost assumed at $0.75 per 1000 lb. No tests are available for moisture entering driers with complete new press clothing, but from a study of results which might be expected, it is assumed that moisture entering under these conditions would be 67.2 per cent.

of vast importance in heat transfer. The drier felt also assists in the removal of moisture.

It has been noted that a new drier felt results in a decreased steam

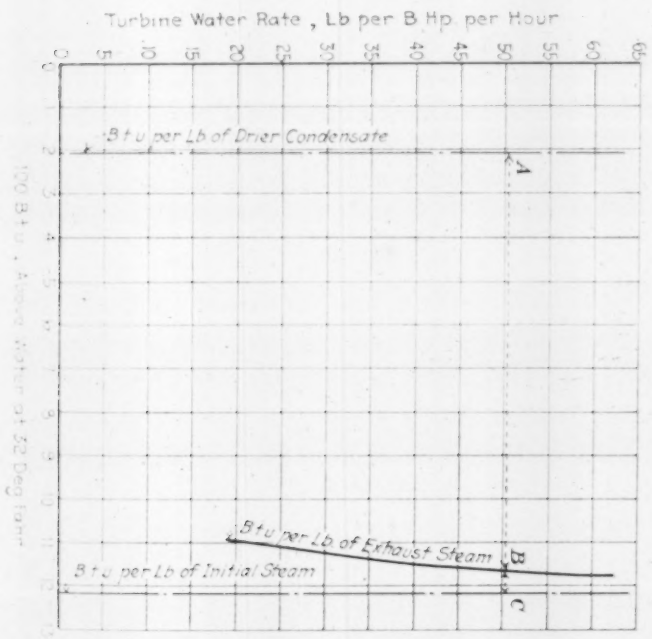
Turbine Water Rate, Lb per B Hp per Hour
B t u per Lb of Drier Condensate
A
B t u per Lb of Exhaust Steam
B
B t u per Lb of Initial Steam
C

FIG. 2 CURVE SHOWING B.T.U. PER LB. OF EXHAUST STEAM AVAILABLE FOR DRIERS

consumption of about 300 lb. per ton of production as compared with an old one. This is due to the fact that as the felt ages, the meshes gradually become closed.

In investigating the action of the driers, that portion of them in intimate contact with the sheet has been termed the "effective" surface, while the remainder has been called "free" surface. In making comparisons between different machines the ratio of the effective surface to the total surface should always be stated.

The amount of radiating surface which does no direct useful work increases with the drier diameter, and to show the effect of diameter on effective surface, Table 3 has been prepared for a 166-in. drier with an actual working face of 156 in. This table is of interest in connection with the design of modern machines, where the high speed required must be obtained either through large diameter of driers or the greater relative speed of those of smaller diameter.

TABLE 3 EFFECT OF DRIER DIAMETER ON EFFECTIVE SURFACE

Diam. of driers, ft.	Total surface in sq. ft. (T)	Effective surface in sq. ft. (E)	Ratio $\frac{E}{T}$
4	199	104	0.523
5	257	130	0.506
6	317	156	0.492

To obtain the maximum value of the ratio E/T, the drier section should be designed so as to obtain as large an arc of contact as possible, consistent with ease of handling paper and changing drier felts. Experience shows that with an open pit under the drier section the life of the felts is materially increased, owing to the better ventilation afforded.

There are two methods in general use for removing condensation from driers, namely, siphons and revolving dippers; and opinions are at variance as to which is to be preferred. Unfortunately,

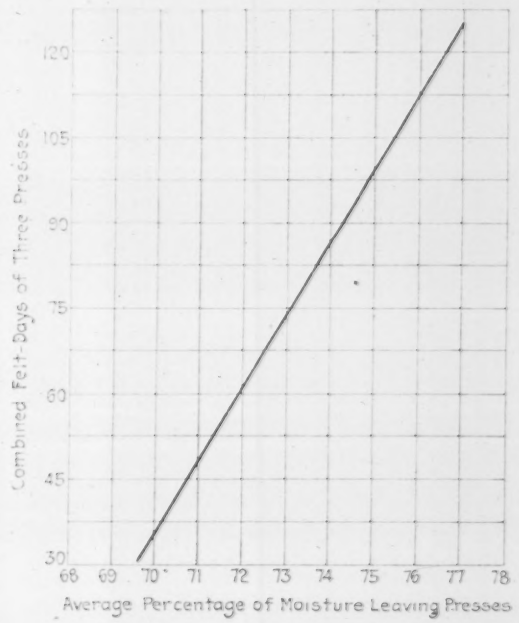

FIG. 3 CURVE SHOWING LIFE OF FELTS IN RELATION TO MOISTURE IN SHEET LEAVING PRESSES

neither system is capable of completely removing all the condensation, and there is always present a small depth of water in the bottom of the driers.

Owing to the fact that the machines must be operated from the front side, it is the practice to locate the inlet and condensation outlet in the back side of each drier. This arrangement does not permit of a uniform or rapid circulation of steam within the driers. It is the authors' opinion that some system whereby a more rapid circulation of steam were made possible, would increase to a considerable extent the heat transfer. This could be accomplished, if it were possible to connect a number of driers in series in such a manner that the circulation of steam would follow the desired temperature gradient.

Air and other incondensable vapors, allowed to accumulate in the driers, retard heat transmission and also result in unequal temperature across the drier face. A suitable air valve should be installed to permit of rapid extraction, without allowing steam to pass.

Absolutely clean internal surfaces are required to obtain maximum heat transfer. With engine-driven machines the internal surface of the driers becomes coated with a film of oil, as oil separators do not completely remove all the lubricant from the exhaust. The turbine, however, requires no internal lubrication, and is therefore superior to a steam engine as a prime mover. The external surfaces must also be kept clean of all accumulations of dirt, grease and lint from the paper.

Superheated steam, while undoubtedly of great value for prime movers, is not desirable for drying purposes, in that it is similar in its properties to gases and parts with its heat much less readily than saturated steam. No doubt some will contend that superheated steam would tend to become saturated by contact with the

condensate, but it is thought that this would take place to a very limited extent. The amount of water in contact with the steam varying from time to time, would result in variations in temperature within the drier. Some expert papermakers contend that superheated steam produces an inferior quality of newsprint as compared with that dried by saturated steam.

The test of the drier part of the machine is given in Table 4. As shown by this table, 269,043 B.t.u. were absorbed by the driers, equivalent to 1342 B.t.u. per pound of moisture evaporated. It

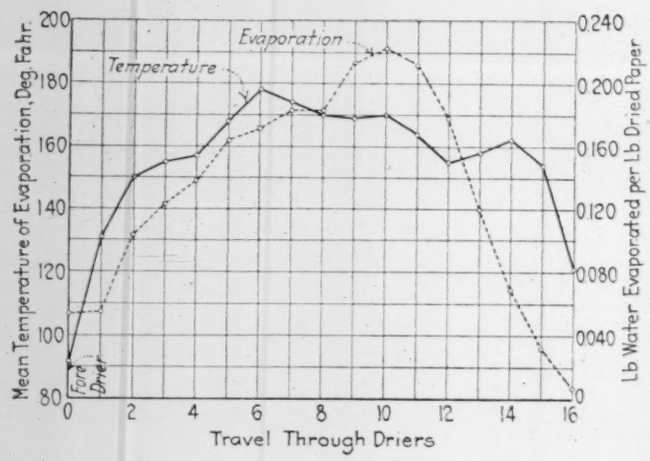

FIG. 4 CURVES SHOWING TEMPERATURE OF EVAPORATION AND WATER EVAPORATED IN DRIERS

will be shown later that the air in passing through the drier sections absorbed 272,837 B.t.u. per min., equivalent to 1361 B.t.u. per lb. of moisture evaporated. The higher value has been used in subsequent calculations.

TABLE 4 TEST OF DRIER

Working width, inches, (deckle)	156
Speed, ft. per min.	650
Effective heating surface, sq. ft.	4401
Total surface, sq. ft.	8272
Ratio of effective to total surface	0.532
Weight of paper (lb. per 500 sheets 24 × 36 in.)	32
Lb. paper dried per minute	90
Percentage of moisture in sheet entering driers	71.5
Percentage of moisture in sheet leaving driers	8.0
Lb. moisture evaporated per lb. of dried paper	2.228
Lb. moisture evaporated per minute	200.5
Steam pressure in driers, lb. per sq. in. abs.	23.7
Temperature of steam in driers, deg. fahr.	248.1
Total heat of steam supplied to driers, B.t.u. per lb.	1164.7
Heat of condensate, B.t.u. per lb.	205.1
B.t.u. absorbed by driers per lb. of steam	959.6
Lb. steam per hour to driers	16,822
Lb. steam per minute to driers	280.37
B.t.u. absorbed by driers per minute	269,043
B.t.u. absorbed by driers per lb. of moisture evaporated	1342

At the time that the test was conducted to determine the heat absorbed by the driers, data were also obtained giving the temperature gradient throughout the driers and the amount of moisture evaporated per pound of dried paper in each increment of travel, as shown by Fig. 4. By integration the theoretical amount of heat required to evaporate the moisture was determined, as shown by Table 5.

It will be noted in this table that 2.228 lb. of water were evaporated from the sheet in its complete travel, and that the theoretial heat required to do this work amounted to 2412 B.t.u. Therefore, the theoretical heat required to evaporate one pound of moisture from the sheet, under the conditions as shown, is 1083 B.t.u.

In making drier calculations it is well to remember that the only useful work performed is the evaporation of moisture from the sheet, and that therefore the theoretical amount, as determined by the conditions of the test, divided by the heat supplied, must give the efficiency of the driers.

Based on the figure of 1342 B.t.u., determined by the drier test, the efficiency is 80.7 per cent, while on the basis of 1361 B.t.u., derived from the air test, it is 79.6 per cent.

To dry paper efficiently the temperature conditions throughout the drier sections must be closely regulated. In the past, temperature control has been obtained by means of a thermostatic valve, which was dependent upon the temperature existing in one drier only. While this has given good results, the latest practice calls for sectional control, which has improved the ease of regulation.

TABLE 5 THEORETICAL HEAT REQUIREMENTS OF DRIERS PER LB. OF PAPER

Drier No.	Moisture leaving drier	% stock in sheet	Lb. water per 0.92 lb. stock	Lb. water evap'ted in travel through drier	Mean temp. of evap., deg. fahr.	Latent heat	B.t.u.	Heat of liquid
	[1]71.5	[1]28.5	[1]2.308	.....	[1]80	.....	.....	.....
Fore	71.0	29.0	2.254	0.054	92	1040.0	56.16	0.65
1	70.5	29.5	2.199	0.055	131	1018.2	56.00	2.81
2	69.5	30.5	2.096	0.103	150	1007.4	103.76	7.21
3	68.2	31.8	1.973	0.123	155	1004.5	123.55	9.23
4	66.6	33.4	1.835	0.138	157	1003.4	138.47	10.63
5	64.5	35.5	1.671	0.164	168	997.0	163.51	14.43
6	62.0	38.0	1.500	0.171	178	991.1	169.48	16.76
7	59.0	41.0	1.317	0.183	174	993.5	181.81	17.20
8	55.2	44.8	1.1336	0.1834	170	995.8	182.63	16.47
9	50.0	50.0	0.9200	0.2136	169	996.4	212.83	19.05
10	43.1	56.9	0.6969	0.2231	170	995.8	222.16	20.07
11	34.5	65.5	0.4846	0.2123	164	999.3	212.15	17.81
12	25.0	75.0	0.3067	0.1779	155	1004.5	178.70	13.34
13	16.9	83.1	0.1871	0.1196	158	1002.8	119.93	9.33
14	11.3	88.7	0.1183	0.0688	162	1001.1	68.88	5.64
15	8.6	91.4	0.0866	0.0317	154	1005.1	31.86	2.35
16	8.0	92.0	0.0800	0.0066	121	1023.9	6.76	0.27
Total				2.2280			2228.64	183.25

[1] Condition of sheet entering the drier.

Without suitable experimental equipment it is very difficult to proportion the total heat transfer into that quantity absorbed by the sheet and that acquired by the surrounding air. It is thought that these quantities, once determined, would be of great assistance to the designers of paper machines, as at present, so far as the authors are aware, all calculations are based on an arbitrary figure.

HEATING AND VENTILATING

Ventilating air supplied to a machine room may be considered as serving three distinct purposes:

1 It maintains such temperatures and humidities within the room that the operators may perform their work in comfort

2 During the period of low outside temperature it supplies sufficient heat to replace the radiation loss from the building

3 It acts as a carrier for the moisture liberated by the machine, so that this moisture is conveyed to the outside air without condensation taking place in the room.

The quantity of air supplied to a machine room depends to a large degree upon the desired machine-room temperature and humidity; and it will be found for the ordinary room, all other conditions considered, that the quantity of air insuring greatest economy is largely exceeded. This practice is only adhered to because of the resulting comfort of the operators.

Even under the best conditions the temperatures found in a machine room are quite high. Particularly is this true in the vicinity of the roof and in monitors, where the average temperature may vary from 80 to 100 deg. fahr. Further, the walls of a modern machine room contain a large glass area, resulting in a considerable heat transfer to the outside air. The radiation loss for the building under discussion may be calculated from the formula $y = 5.1 - 0.0583x$, where y is the radiation loss per pound of air in B.t.u., and x the outside or initial air temperature in deg. fahr. This formula is based on an exhaust-fan discharge of 5422 lb. of air per minute, and it shows that the radiation loss from the building makes a very appreciable demand upon the heating load for ventilation.

The air supplied for carrying away the moisture from the machine may be considered as ventilating the machine, apart from the ventilation of the room. This air, in its passage through the machine room, acquires from the wet end a certain amount of moisture, but no heat, and from the driers, both moisture and heat. It must, therefore, when expelled from the room, contain this moisture and heat, together with that which it contained whem coming in contact with the machine. Provided, therefore, that the initial and final conditions of the air are known, and also its quantity per unit of time, the amount of moisture and heat liberated by the machine can be readily calculated.

In order to determine these quantities, so that they could be used as constants in further calculations, a test, previously referred to, was conducted on a still day in summer when the machine-room windows were all open and air of a uniform temperature was supplied to the room. The advantage of making this test in summer rather than in winter is apparent when it is considered that in winter considerable leakage takes place through openings from adjoining buildings and from the outside air, which renders it difficult to arrive at a representative value of the temperature and relative humidity of the incoming air. Also the outside tempera-

ture at the time being 83.3 deg. fahr., the radiation loss from the building could be neglected without introducing any appreciable error. The results of this test are shown in Table 6.

In making this test the discharge of hot air from each of the stacks was determined by dividing their rectangular cross-section into 24 equal divisions, and the velocity at the center of each of these divisions was determined by means of an anemometer. Wet- and dry-bulb temperatures were taken at the same time, and the discharge as computed in cubic feet per minute was converted into pounds per minute. Carrier's pyschometric charts were used to determine the moisture per pound of dry air and the total heat above 0 deg. fahr. per lb. of air. These charts were of great assistance in simplifying the calculations.

It is thus seen that the quantity of heat given up by the driers per minute as calculated on the ventilating-air basis, checked that as calculated on a steam basis within 1.5 per cent.

TABLE 6 VENTILATING-AIR TEST

	Stack No	Dry-bulb temp., deg. fahr.	Wet-bulb temp., deg. fahr.	B.t.u. per lb. of air above 0° F.	Grains moisture per lb. dry air	Lb. air per min.	Lb. dry air per min.	Lb. moisture in air	B.t.u. above 0° F. contained in air
Final air in stack	1	110	108.5	85	396	1788	1692	96	151,980
	2	118	107.0	82	360	1766	1680	86	144,812
	3	121	113.0	95	445	1868	1756	112	177,460
	Total					5422	5128	294	474,252
Initial air entering room		83.3	76	38.6	123.3	5218	5128	90	201,415
Difference in moisture and heat content between final and initial air								204	272,837

The difference between the moisture acquired by the air, 204 lb., and that liberated by the driers, 200.5 lb., can, in the opinion of the authors, be reasonably taken as the amount of moisture acquired by the ventilating air from the wet end of the machine, and in this case amounted to 3.5 lb., or less than 2 per cent of the total.

When, therefore, the machine is operating at 650 ft. per min. and 5422 lb. of air are expelled by the exhaust fans, the heat given up by the machine per minute is 272,837 B.t.u. and the moisture liberated in the same time is 204 lb.

If then values are assumed for the initial air condition, it is possible, by utilizing the above figures, to determine the final moisture and heat content of the air per pound, and by comparing the heat content of air containing this moisture with that of air containing the same moisture and at saturation, or 80 per cent relative humidity, it is possible to determine to what degree the initial outside air must be heated before entering the machine room, in order that it may function properly.

It must be borne in mind that the above statement presupposes that for low outside-air temperatures the ventilating air is preheated before admission to the machine room. Consequently, upon reaching the machine its temperature will be practically the same as applied when the test was made, and therefore the heat transfer from the driers, and the moisture absorbed from the wet end, will not, for practical purposes, be changed.

Table 7 has been prepared on a basis of initial air at 70 per cent relative humidity. From this table Fig. 5 has been plotted, which serves the purpose of estimating the machine heating load for various outside temperatures.

By referring to Fig. 5, it is seen that for the ventilation of the machine only, there is some critical temperature, in this case 66 deg. fahr., below which the outside or initial air must be preheated before coming in contact with the machine. In practice, however, this critical temperature would be slightly higher, as it is not common practice to expel the air from the machine room at a relative humidity (R. H.) as high as 100 per cent. If the final air had a relative humidity of 80 per cent, the critical temperature would be 78 deg. fahr.

By combining the quantity of heat per pound of air required by the machine with that necessary to replace the radiation loss from the building, the total heat per pound of air required for the purpose of ventilation can be determined.

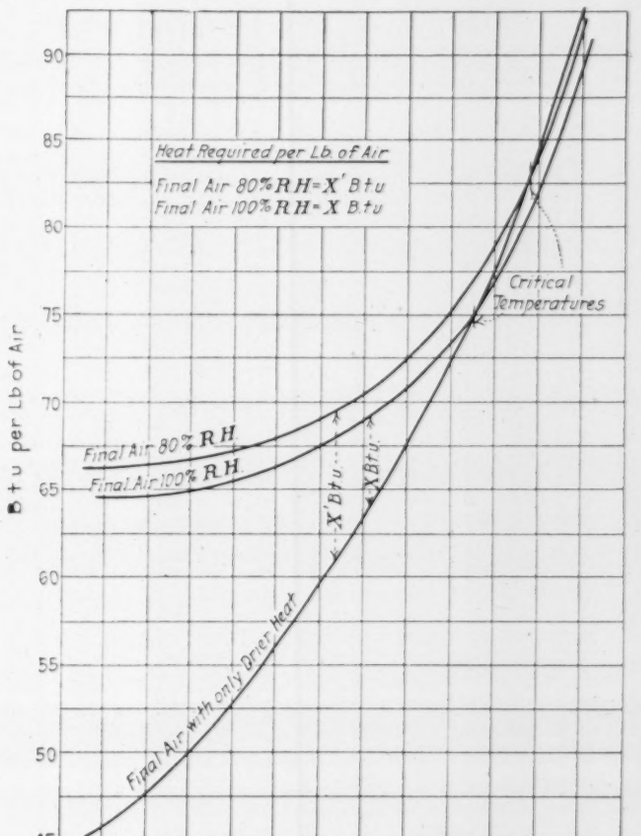

FIG. 5 CURVES SHOWING HEAT REQUIRED FOR PAPER-MACHINE VENTILATION

The important factor which influences the ventilating requirements of a paper mill is the amount of moisture liberated by the machine per unit of time. This in turn is dependent upon:

1 Speed of the machine
2 Moisture in sheet entering the driers
3 Moisture in sheet leaving the driers
4 Moisture absorbed from the wet end.

TABLE 7 SHOWING CHANGE IN AIR CONDITION WHILE PASSING THROUGH THE MACHINE

Initial Air Condition							Absorbed From Machine			Final Air Condition							
Temperature °F.	% Relative Humidity	Gr. Moisture per lb. of dry air	Heat above 0°F. per lb. of air, B.t.u.	Lb. of air per min.	Lb. dry air per min.	Total moisture, lb.	Total heat, B.t.u.	Moisture from wet end, lb.,	Moisture from driers, lb.	Heat from driers, B.t.u.	Total air, lb.	Total Moisture, lb.	Dry air lb.	Gr. moisture per lb. of dry air	Heat above 0°F. in total air, B.t.u.	B.t.u. per lb. of air	B.t.u. per lb. of air, 100% R. H. and same moisture	B.t.u. per lb. of air, 80% R. H. and same moisture
—20°	0	0																
+10	70	6.5	4.8	5218	5218	0	—25046	3.5	200.5	272,837	5422	204	5218	274	247,791	45.7	64.5	66.3
30	70	17.0	2.5	5218	5213	5	13045	3.5	200.5	272,837	5422	209	5213	280	285,882	52.7	65.5	67.1
40	70	25.6	9.75	5218	5205	13	50876	3.5	200.5	272,837	5422	217	5205	292	323,713	59.6	67.5	69.0
50	70	37.3	13.6	5218	5199	19	70965	3.5	200.5	272,837	5422	223	5199	301	343,802	63.3	69.0	70.5
60	70	54.0	17.9	5218	5190	28	93402	3.5	200.5	272,837	5422	232	5190	313	366,239	67.5	70.7	72.4
70	70	76.0	22.8	5218	5178	40	118970	3.5	200.5	272,837	5422	244	5178	330	391,807	72.2	73.3	75.2
80	70	107.0	28.3	5218	5162	56	147669	3.5	200.5	272,837	5422	260	5162	353	420,526	77.5	76.8	79.0
90	70	149.2	35.6	5218	5140	78	185761	3.5	200.5	272,837	5422	282	5140	384	458,598	84.5	82.3	84.2
			44.2	5218	5110	108	230636	3.5	200.5	272,837	5422	312	5110	427	503,473	92.7	89.4	91.6

The old practice, therefore, of specifying paper-mill ventilation on a basis of so many minutes air change, without due regard to the moisture liberated, is not correct, as it is obvious that the amount of moisture liberated in two machine rooms of the same size might be entirely different.

Much of late has been written regarding the proper distribution of air in the machine room, but it is not the intention of the authors to discuss this further, except to state that, in their opinion, the greater part of the ventilating air should be delivered in the vicinity of the driers and the wet end, so that the moisture may be confined at its source. Further, that sufficient warm dry air should be supplied to the roof and all pockets, such as monitors, in order that

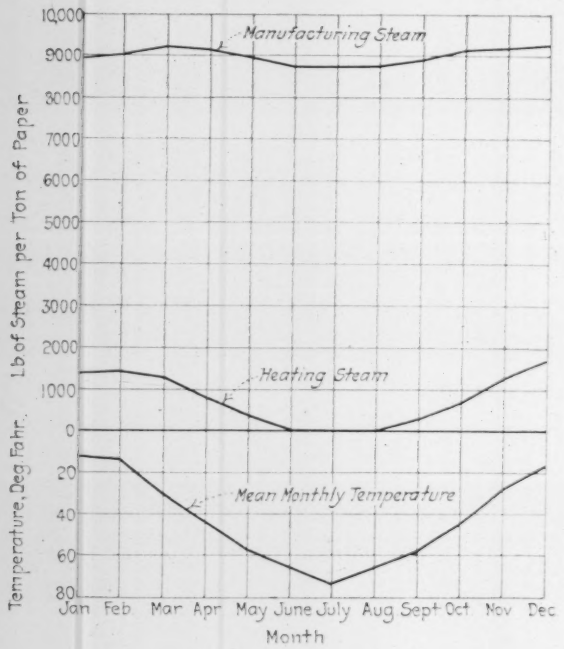

Fig. 6 Curves Showing Temperature and Steam for Manufacturing and Heating, by Months

the moisture-laden air shall not become chilled below the dewpoint, causing drip.

The amount of heat lost to the process by the expelled ventilating air is in all probability the greatest unpardonable waste in the manufacture of paper.

By referring to Table 7, it can be seen that, with initial air at 10 deg. fahr. and of 70 per cent relative humidity, the total heat above zero deg. fahr. is 2.5 B.t.u. per lb., and the heat content of a pound of final air at 100 per cent relative humidity is 65.5 B.t.u. above 0 deg. fahr., the difference in the heat content per pound of air being 63 B.t.u.

Only 12.8 B.t.u. per lb., however, have to be furnished in order to preheat the incoming air, the balance of this difference being supplied by the driers. It is here that an economizer could be used to great advantage in reclaiming from the expelled air enough heat to condition the incoming air.

Owing to the high relative humidity of the outgoing air, a few degrees' drop in temperature in the economizer would be sufficient to supply heat necessary to preheat the incoming air, with the result that no live or exhaust steam would be required for ventilation.

The saving in operating cost which would result in winter from such an installation is apparent when it is considered that, for the conditions under consideration, at least 5900 lb. of dry steam, at 10 lb. per sq. in. pressure, would be required per hour for preheating the ventilating air when the outside temperature was 10 deg. fahr. and the relative humidity 70 per cent.

Fig. 6 shows for the period of one year the manufacturing and heating load in pounds of steam per ton of product, also the mean monthly temperature which prevailed. It is interesting to note the relative importance of the heating load, and it can be readily realized that the manufacturing cost could be considerably reduced if, by the installation of an economizer, this were done away with.

Conclusion

This paper does not make a complete survey of the subject under discussion, but the authors, in seeking to collect material for the subject-matter, have been impressed with the lack of detailed information which is available. It may be that some mills have studied their problems in great detail, but if so, the information is treated as strictly confidential. It can be understood that, once a paper machine is installed, the owners are reluctant to decrease production while making experimental tests. Therefore, paper-machine manufacturers are unable, in certain respects, to procure reliable operating data upon which to base their designs.

TESTS ON WELDED CYLINDERS

(Continued from page 586)

Oxide inclusions along the surfaces joined by forge welding are practically inevitable. Where an oxide inclusion exists the union between the two pieces welded together is obviously imperfect, thus weakening the weld.

If the forge-welding process is to be used it is recommended that decisive steps be taken toward much more careful temperature control.

The work also indicates clearly that the best type of vessel tested was that made up of a seamless-pipe shell with acetylene-welded dished heads, convex outward. This construction places the welds where they have to sustain a minimum stress and eliminates the danger of a failure such as occurred in the cases of cylinder No. 4.

In the five cylinders tested there were two acetylene-welded longitudinal seams and six acetylene-welded circumferential seams, a total of eight important acetylene-welded seams. The authors were able to rupture but one of these, a longitudinal seam. Very slight leakage was obtained at one other, a circumferential seam. Of the four forge-welded seams every one failed by excessive leakage at pressures considerably lower than those safely sustained by the acetylene welds.

There were a total of 28 pipe fittings acetylene-welded to the five cylinders. Leakage was observed through two of those, in each case finally resulting in failure.

The tests also indicate that the acteylene welds are likely to have occasional porous spots and that pinholes may often develop when high pressures are reached. They also indicate that the welds where fittings for pipe connections are joined to the vessel are almost as likely to cause failure as are the longitudinal and circumferential seams.

The acetylene welds also have non-metallic inclusions, but they are more globular in form than those found in the forge welds and are also scattered in all directions through the material instead of being concentrated along the contact surface. They are therefore less likely to cause leakage.

The principal defects in the acetylene welds examined seem to be the coarse granular structure and porous spots obtained and the occasional poor adhesion of the welding material to the original plate. Poor adhesion may be due to the plate cooling below a good welding temperature, or becoming oxidized along the surface before the welding material is added. These defects suggest the following possible remedies:

a The plate should be heated for as short a distance ahead of the fused-in material as possible. This should render cooling less likely and reduce the chance of oxidation.

b The work should be done as rapidly as possible in order to reduce the grain size to a minimum. As low a temperature as possible, consistent with good welding, is desirable for the same reason.

c The weld should be cooled as soon as possible after being made, in an effort to reduce the growth of ferrite crystals.

d Possibly oxide inclusions might be reduced by using a flame so adjusted as to be neutral or slightly reducing rather than oxidizing in nature. This would require some experimentation.

e Defects in welding attachment couplings to shells or heads, similar to those which caused the failure of cylinders Nos. 2 and 5 (see Fig. 14), could probably be avoided by scarfing the edge of the hole into which the coupling is set. While defects of this character can be avoided by careful workmanship, it would seem that scarfing would render the difficulty much less likely to occur. A scarfing tool similar to a pipe reamer could be devised easily.

f In the case of the samples of seams examined, poor adhesion was noticed in a number of cases, particularly at the bottom of the weld. This might be improved by scarfing both edges to be joined and carrying the bevel nearly if not quite to the bottom of the plate.

Progress in Synthetic-Gasoline Production

Particulars Regarding the Processes Employed—Results of Tests of an Improved Synthetic-Crude System—Comparative Costs of Manufacturing Gasoline by Different Processes

By DR. ROY CROSS,[1] KANSAS CITY, MO.

AT THE present time gasoline and other motor fuels have three principal sources, the chief of these being the gasoline found in natural crude petroleum, which amounts to about 70 per cent of the total production of the United States. The next most abundant source is synthetic gasoline, which supplies about 23 per cent of the total. The light gasoline obtained from natural gas amounts to about 5 per cent of the total, while coal furnishes about 2 per cent of the total in the form of benzol or naphtha.

Assuming that there may be no increase in the production of gasoline-bearing crude oil, we may consider the possible expansion in gasoline production on the basis of the present production of crude. Crude oil must first supply for other purposes about 26 per cent of its volume, consisting of lubricants (6 per cent), kerosene (10 per cent), and indispensable miscellaneous petroleum products and losses (10 per cent). With an average natural gasoline content of 20 per cent, 46 per cent of the natural constituents of crude oil is not an additional source of gasoline. Of the remainder (54 per cent), nearly 60 per cent, or 30 per cent of the original crude oil, can be made into synthetic gasoline, of which something like 5 per cent is now made. This makes a total of 25 per cent of the present crude production available for making gasoline and which is not now made use of. A sufficient amount of fuel oil still remains to take care of those industries which require fuel oil to the exclusion of coal. In other words, the possible production of gasoline with the present production of crude may be doubled without disorganizing other industrial requirements for oil.

It is quite apparent that the amount of gasoline from natural gas is limited. The supply of motor fuel from coal distillation is likewise limited by the requirements for the main products from coal. The immediate future source of gasoline, then, must come from cracking unless crude-oil production increases more rapidly.

Decomposition of Heavy Petroleums

When crude oil is subjected to ordinary distillation by fire the light products naturally present in the oil are distilled off as such up to a temperature of about 300 deg. cent. (572 deg. fahr.), comprising both the gasoline and the kerosene. Above this temperature the hydrocarbons undergo partial decomposition while distilling, with the result that some light products are produced and distilled along with the heavy products. Olefins as well as paraffin compounds of lower molecular weight than the oil being heated are formed. By vigorous firing, the entire oil residue may be distilled, leaving only a variable amount of residual carbon as a product of decomposition. The amount of carbon and gas formed by this pyrogenic decomposition is greater with the asphaltic or naphthene petroleums than with the paraffin-base petroleums.

This property of all heavy petroleums of decomposing into hydrocarbons of lower molecular weight by heating is generally known as "cracking." The chemical reactions involved in cracking are not definite. It was originally supposed that cracking involved the formation of a large amount of olefins according to the following reaction:

$$C_nH_{2n+2} = C_{n-m}H_{2(n-m)+2} + C_mH_{2m},$$

a specific illustration of which would be—

$$\text{Pentadecane} = \text{Octane} + \text{Heptylene}$$
$$C_{15}H_{32} = C_8H_{18} + C_7H_{14}$$

This reaction however, does not, accord with the facts, since gas and carbon are always formed in varying amounts. A reaction which corresponds to the yields as were found experimentally under certain conditions is the following equation:

$$2C_nH_{2n+2} = 2C_{n-m}H_{2(n-m)+2} + mCH_4 + mC$$

or as a specific illustration—

$$C_{15}H_{32} = C_8H_{18} + 7CH_4 + 7C$$
$$\text{Pentadecane} = \text{Octane} + \text{Methane} + \text{Carbon}$$

Yet under certain other conditions the amount of gas formed is very small, indicating that the following reaction was partly carried out:

$$(2m+2)\,C_nH_{2n+2} = (2n+2)\,C_nH_{2n+2} + 2(n-m)C$$

or as an illustration:

$$\text{Pentadecane} = \text{Octane} + \text{Carbon}$$
$$9C_{15}H_{32} = 16C_8H_{18} + 7C$$

The cracking of oil is not simply a decomposition of the hydrocarbon molecules. Both heavier and higher-boiling hydrocarbons as well as lighter and lower-boiling hydrocarbons are produced simultaneously. There must be polymerization to yield hydrocarbons of both higher boiling point and higher specific gravity. By continued cracking there may be made from water-white distillate, solid and ductile asphaltic cement of typical conchoidal fracture.

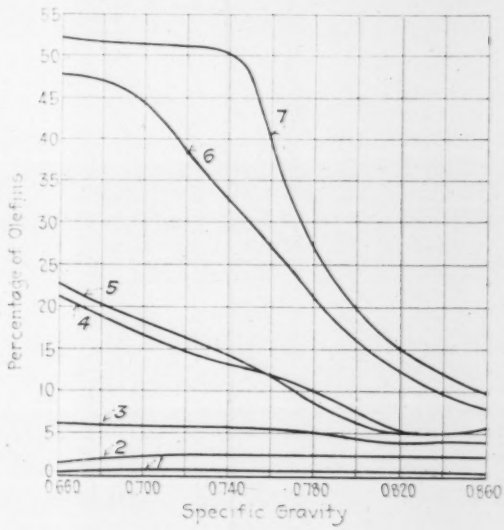

Fig. 1 Olefins or Unsaturated Compounds in Various Fractions Made by Different Processes

(1, Aluminum chloride process; 2, Burkburnett crude oil; 3, High-pressure cracking (750 lb.); 4, Burton process; 5, Low-pressure process; 6, High-temperature process; 7, High-temperature vapor-phase process.)

The gases produced by cracking likewise are not simple split-off hydrocarbons, but vary according to the method of cracking. In liquid phase cracking the chief variation is in the olefin and hydrogen content. In a general way there seems to be a tendency for low percentages of hydrogen to be associated with low percentages of olefins. A typical gas made in a Burton still gives the following percentage analysis: Methane and ethane, 82; olefins, 8.5; hydrogen, 9.5.

One of the problems in cracking is to limit the amount of hydrogen lost in the gas. This has been partly done by allowing the hydrogen to remain in contact with the cracked distillate under high pressure and at a temperature somewhat below the ordinary temperature of cracking.

Fig. 1 shows some of the relative properties of light hydrocarbons made by various processes used more or less in a commercial way for the production of gasoline from heavy oil. Gasoline made

[1] K. C. Testing Laboratories.

Abridgment of a paper presented at the Kansas City Regional Meeting of The American Society of Mechanical Engineers, March 6–7, 1922. All papers are subject to revision.

by the aluminum chloride process has the lowest percentage of olefins—even lower than gasoline made from natural crude oil. Gasoline made from synthetic crude comes next in order of quality. Gasoline by the pressure-distillate system is much superior to gasoline made by the high-temperature vapor-phase processes.

There are more than a thousand devices or processes relating to the production of synthetic gasoline on which patents have been issued by the United States Patent Office. Very few, however, are practical, and those that are have been made commercially successful only by extensive mechanical experiments.

Processes Employed in the Manufacture of Synthetic Gasoline

The most important matter in the commercial production of gasoline is that of cost. There are many organic substances from which gasoline may be made, including shale oil, vegetable oil and animal oil. In the laboratory it is possible to make high-grade gasoline from fish oil and the time may arrive when we shall depend upon this source for our gasoline, but at present the process is commercially impossible for obvious reasons. The most important processes for the production of gasoline commercially as well as from the standpoint of technical interest may be grouped as follows:

1 *Vapor-Phase Systems.* These are the outgrowth of the old processes for making Pintsch gas, oil gas, Blau gas and the like.

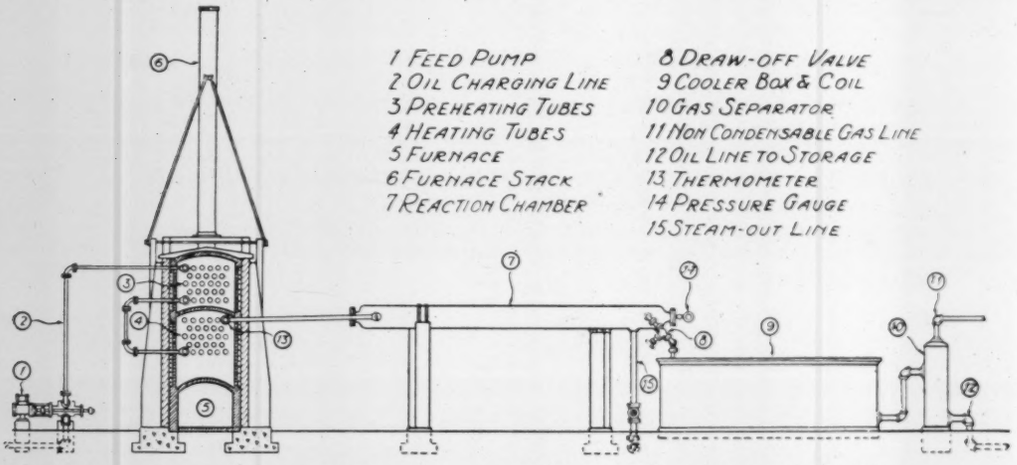

Fig. 2 Synthetic-Crude System in which the Heating and Reaction Zones Are Distinct

They employ very high temperatures, usually above 1500 deg. fahr., and the products are of the nature of unsaturated compounds and aromatic compounds. Some of these processes use steam or natural gas mixed with the oil vapor, and various mechanical devices are employed to prevent the accumulation of carbon in the tubes. Some are operated under considerable pressure, among them being the Rittman process, which operates at a temperature of 950 deg. fahr. and upward, and the Hall (1100 deg. fahr. and upward). Others in this group are the Greenstreet and the Parker processes. By using lower temperatures, products containing a large amount of paraffin hydrocarbons or gasoline may be obtained, and some practical work is now being done in cracking oil vapors at temperatures as low as 800 to 950 deg. fahr.

One of the most recent patents for cracking oil in the vapor phase provides for heating the vapor of gas oil as it comes from the crude still. The cracked vapor is then sent into a dephlegmator where the gasoline is separated and condensed. The uncracked portion is returned to the still. This method saves the fuel expense required to heat the gas oil for the second time. Electrical sources of heat have been used, but are considerably more expensive and therefore impractical. No truly catalytic processes have been commercially developed for the cracking of oil.

2 *Pressure-Distillate System.* Nearly all of the synthetic gasoline now placed on the market is made by the pressure-distillate system. The most outstanding example of it is the Burton process, the total still capacity of which in 1921 was 200,000 bbl., with an output of 2,000,000 gal. of gasoline per day. Other processes operating on this general system are the Dubbs, Coast, Jenkins, Isom, Adams, Fleming, Dewar and Redwood, Bacon and Clark, and E. M. Clark's modification of the Burton process. All of these systems operate under pressure, some with pressure on the condenser and some without, the pressure on the condenser being merely an economical means of condensing. The production of pressure distillates with this type of process is an operation necessity and refined distillate is obtained in practically none of them. The pressure distillate must be rerun and the crude benzine treated in essentially the same manner as a natural crude oil. It is in this type of process that litigation chiefly exists.

The chief disadvantages of this method of operation are the large fuel consumption, the large amount of oil under treatment at one time, the slowness of the conversion, and the expensive plant equipment.

3 *Chemical Methods.* When the heavy fractions of petroleum distillates such as kerosene, gas oil or paraffin oils are slowly heated with a small quantity of perfectly dry and active aluminum chloride, the salt dissolves, imparting a reddish to black appearance to the solution. If this dark liquor is then subjected to slow fractional distillation at a temperature below that at which aluminum chloride volatilizes, a sweet, water-white light distillate is obtained having all the properties of light high-grade gasoline that has been subjected to complete refining with sulphuric acid. Other chemicals which have essentially the same effect as aluminum chloride but to a lesser degree are anhydrous ferric chloride, tin chloride, manganic chloride, zinc chloride and phosphorus pentoxide. In the experience of the author, about 60 per cent of 55 deg. B. water-white naphtha can readily be obtained by this process with one distillation. The advantage lies in the fact that the product is completely refined. However, large quantities of hydrochloric acid gas are given off in the distillation, and the residue has very little value. The chief commercial disadvantages are the excessive cost of aluminum chloride, the loss of the fuel-oil residue, and the corrosive action of hydrochloric acid. Aluminum chloride requires the use of molecular chlorine, which cannot be made at this time at a sufficiently low price to allow its employment for competing with the straight heat processes for making gasoline.

4 *Synthetic-Crude Systems.* This method of operation presents at this time the greatest possibilities in reducing operating costs. There are three types:

a The intermittent-digestion type, in which a charge of oil is subjected to heat and pressure until reaction takes place and then is completely discharged. Representatives of this type are the Palmer and the Snelling processes. The disadvantages are the low yield per cycle, the time required for cooling, and inability to operate continuously.

b The type in which a body of oil is continuously charged and heated and more or less continuously discharged. The heating and reaction containers or zones are one and the same. The chief disadvantage is the limitation of the cycling time on account of the rapid accumulation of carbon in the reacting zone and its effect on the transfer of the furnace heat. The Hubbard patent is of this type.

c The third class is the type in which the heating and reaction zones are separate and distinct. This type is covered by one patent and provides for continuous operation and rapid conversion. Outstanding advantages are the long cycle (about one week) before cleaning—due to absence of carbon in the heating zone, the great speed of reaction (15 min.), the large ultimate yields (700 bbl. per day per unit), and the great capacity per unit of cost.

One or more units of the process may be added to any refinery merely as an adjunct, without any change in ordinary refinery

operation. With this process added a greater still capacity is necessary for a given amount of crude oil, or greater yields may be obtained with the same still capacity and with a smaller amount of crude oil available.

The scheme of operation is that shown in Fig. 2. The steam pump 1 forces the charging stock against the pressure in the apparatus through line 2, passing it from above downward through the preheating tubes 3 in the upper part of the furnace. No decomposition or cracking takes place in these upper tubes since they merely serve as fuel economizers, while the pressure in the apparatus is sufficient to maintain the oil in the liquid condition. The oil passes from these preheater tubes into the lower furnace tubes 4, starting in at the bottom. In this furnace the main absorption of heat takes place. The oil temperature is registered as it issues from the heating tubes at the point 13. The temperature of the oil and the character of the oil under treatment govern the rate of pumping. At the point 13 all of the heat has been applied to the tubes, but the oil has not yet been converted as the time element is lacking. It is therefore discharged into the reaction chamber 7, where it is held a sufficient length of time for an equilibrium to be reached between the vapor phase and the liquid phase. Ordinarily this requires less than 15 min. The discharge line through the valve 8 is set at the liquid level and perfectly controls this level without any other automatic device than an ordinary relief valve. The oil is then discharged through the cooling coil line 9 under a pressure of approximately 40 lb. and into the gas separator 10, from which the gas goes out through the line 11 and the oil is discharged through the line 12 to storage. This synthetic crude is run in the ordinary skimming plant in the usual manner.

A flow sheet for a complete gasoline plant in which all of the crude is made into gasoline and fuel oil is shown in Fig. 3. It is of course not advisable to run all of the residue into gasoline, as a point is eventually reached at which the fuel oil becomes so heavy that the gasoline yields are relatively poor.

Table 1 shows a typical run according to the synthetic crude process in which the heating zone and the reaction zone are kept separate. This plant is equipped with a forge-and-hammer-welded vapor chamber, which is being replaced in new plants now being built by reaction chambers made by the Midvale Steel & Ordnance Co. These chambers are approximately 38 in. in inside diameter and with walls 3 in. thick. With this chamber the cycle one week, one day per week being required for cleaning. This is made possible by reason of the increased size, as the carbon accumulates in the reaction chamber and eventually fills it to such an extent that the plant must be closed down for cleaning.

TABLE 1 DATA OF RUN NO. 44 AT CRACKING PLANT NO. 1
(January 21–25, 1922)

Oil used, bbl.	3030
Cracked oil delivered, bbl. (shrinkage, 4 per cent by volume)	2909
Gasoline produced, bbl.	727
Fuel used (1/8 bbl. per bbl. of gasoline produced)	91
Hours on steam	96
Hours on fire	98
Oil cracked per hour, bbl.	31.5
Fuel used per hour, bbl.	0.95
Maximum oil temperature, deg. fahr.	915
Average oil temperature, deg. fahr.	900
Maximum furnace temperature, deg. fahr.	1375
Maximum stack temperature, deg. fahr.	765
Average stack temperature, deg. fahr.	740
Pressure, lb. per sq. in.	600

The most severe strain on the apparatus is from the cooling of the reaction chamber when the plant is closed down for cleaning out the carbon. This strain tends to open welded joints but does not affect the body of the metal. All welded joints have now been eliminated with the use of the chamber forged from a single ingot.

A summary of total ultimate yields as obtained in plant No. 1 the same oil being recycled without the addition of fresh oil to the system, is as follows:

Gas oil used	10,475 bbl.	= 100.0 per cent
Gasoline	6,789 bbl.	= 64.8 per cent
Fuel oil	2,600 bbl.	= 24.8 per cent
Loss	1,086 bbl.	= 10.4 per cent

As to the profits accruing from plant No. 1, the data given in Table 2 are representative of one month's operation.

Comparative Costs of Making Gasoline

While there is much variation in the absolute cost of making gasoline by any process, Table 3 outlines the comparative costs of operation of one unit of three principal systems. No satisfactory information is available for vapor-phase processes.

For convenience in estimating the cost of manufacturing gasoline the following formulas may be used as approximations. It is to be observed in these formulas that under present commercial conditions gasoline may be made by cracking methods very much more cheaply than by the skimming of natural crude.

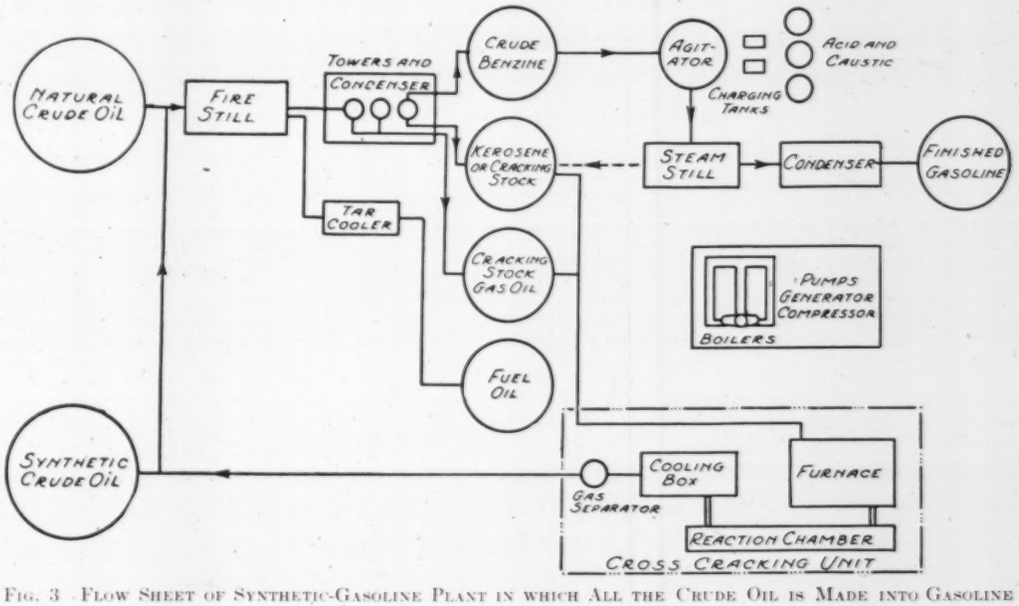

FIG. 3 FLOW SHEET OF SYNTHETIC-GASOLINE PLANT IN WHICH ALL THE CRUDE OIL IS MADE INTO GASOLINE AND FUEL OIL

TABLE 2 RESULTS OBTAINED FROM ONE UNIT, CRACKING-PROCESS PLANT NO. 1, FOR MONTH OF JANUARY, 1922

Charges:	
15,427 bbl. gas oil used @ $1.575	$24,297.53
420 bbl. fuel used @ $1.575	661.50
Total payroll charge for month	1,365.79
Storeroom charges for month	55.78
Fixed charge, 31 days @ $32.00	992.00
Steam, air, etc., 31 days @ $20.00	620.00
Distilling and treating 14,852 bbl. @ $0.35	5 201.70
Total charges	$33,192.30
Credits:	
4,186 bbl. gasoline @ $6.09	$25,492.74
10,622 bbl. oil returned @ $1.47	15,614.34
Total credits	$41,108.08
Less charges	$33,192.30
Estimated profit for month	$ 7,914.78

TABLE 3 COST PER BARREL OF MAKING GASOLINE BY THESE PRINCIPAL SYSTEMS

	Synthetic-crude system	Pressure-distillate system	Aluminum chloride system
Labor	$0.30	$0.90	$0.90
Materials	0.16	0.20	2.60
Fuel oil @ $1.00 per bbl.	0.10	0.40	0.40
Overhead	0.20	0.20	0.20
Fixed charges	0.25	0.75	0.60
Rerunning	1.20	1.20	0.00
Gas oil equivalent to converted gasoline	1.25	1.25	1.25
Refining loss	0.20	0.20	0.20
Degrading of gas oil	0.06	0.06	0.60
License charges	0.20	0.20	0.20
Cost per bbl.	$3.92	$5.36	$6.95

(Continued on page 621)

SURVEY OF ENGINEERING PROGRESS

A Review of Attainment in Mechanical Engineering and Related Fields

Thermo-Calorimetric Heating Values of Fuels

By J. HUDLER

THE author brings out that a purely calorimetric determination of the heating value of a fuel is insufficient when dealing with fuels containing considerable quantities of moisture. If it should be desired to raise in a boiler the same amount of steam per hour with fuels containing high quantities of moisture as was previously done with coal, it is possible to attain such a result, but only by permitting a higher temperature in the smokestack. The lower production in units of steam per hour due to the burning on one part of the grate of wet fuels must be compensated for by an increased consumption of fuel on some other part of the grate. This can be done by burning more fuel per hour, in which case the initial temperature, owing to the greater amount of smokestack gases, falls off much slower, and the gases go to the smokestack with a higher temperature. Therefore the more moisture the fuel contains the lower will be the useful temperature head as the result of lower initial temperature and higher exhaust temperature, while the amount of exhaust gases per unit of heat will be greater. It is easy to understand what happens when burning fuels with a high percentage of moisture. It is this state of affairs that forced the adoption of larger grates on the new locomotive boilers in Austria.

At the same time, high moisture content of the fuel leads to placing the fuel in a low-grade classification, which, however, is not indicated calorimetrically. Because of this, purely calorimetric testing becomes insufficient. On account of the decisive influence of smokestack temperature on steam output per hour and furnace losses, it is impossible to obtain a clear idea as to the value of various fuels without considering the various furnace temperatures, as these are influenced by the composition of the fuels.

The author proceeds to indicate a method for determining the heating value of fuels which he claims is superior to the straight calorimeter method. The new values are of particular interest for the purpose of comparing fuels to be used for steam generation.

To do this he considers various fuels as being burned under the same boiler with the same excess of air and at the same air temperature, and with the same output of steam per hour, and then determines the useful heat per kilogram (2.2 lb.) of the fuel. This gives a series of values which the author calls thermo-calorimetric heating values. These values are not absolute for a given fuel, but show the comparative values of various fuels, which is just what is necessary to know in purchasing fuels.

If H_u is the calorimetrically determined heating value, W_A the heat loss through unconsumed carbon in the ash, W_V the loss through radiation and conduction of the boiler setting walls, and W_R the loss through smokestack gases, then the useful heat is $W = H_u - W_A - W_V - W_R$. H_u is given; W_A can be determined by ash analysis; W_V may be considered as known for a given installation; as regards W_R, we know the composition and volume of the smokestack gases, but not their outlet temperature. Recourse can, however, be had to an important factor which hitherto has not been sufficiently considered in furnace operation, namely, that each fuel has its specific initial temperature, to which for a given constant output of steam there must correspond a certain outlet temperature. This may not be observed in some cases: in particular, in comparisons between two fuels burned under the same boiler. This may be due to the fact that with fuels which give a higher steam output, lower outlet temperatures have been found to prevail for a given output of steam.

In determining his thermo-calorimetric series of values for the various fuels, the author started with a good grade of coal and assumed that in that event the smokestack gases leave the boiler heating furnace with the temperature of 300 deg. cent. (572 fahr.), whereas, the temperature of the boiler water is 183 deg. On this assumption the heat output per hour, which must be the same for all fuels, is so determined that in each case it becomes possible to compute the exhaust temperature of the gases.

Case of Coal Firing

It is assumed that the coal fired under a boiler has the following composition: Carbon, 0.760; hydrogen, 0.046; oxygen, 0.060; water, 0.040; ash, 0.095; H_u is 7456 large calories per kg.

The author has previously established the following formula:

$$W = C \frac{T_o - T_1}{\log \frac{T_o - t}{T_1 - t}}$$

where W is the heat in large calories per hour transmitted to the boiler; T_o the calculated initial temperature in degrees centigrade; T_1 the outlet gas temperature; t the temperature of the boiler water; and C a constant expressing the heated area and the coefficient of heat transmission. Since the actual initial temperature of combustion is smaller than the calculated temperature, an objection might be made to the above formula on the ground that it is apt to give the useful heat head greater than it actually is; but at the moment of its appearance the flame radiates amounts of heat on to the surrounding heated surfaces which are proportional to the difference between the temperatures of the respective surfaces and the temperature of the flame. This heat radiation produces a lowering in the temperature of the flame, whereas in calculation this temperature is determined on the assumption that no heat is being lost from it. Because of this, the temperature head computed on the basis of the temperature T_o determined by measurement would be too small as a basis for establishing the quantity of heat given up to the surrounding surfaces. On the other hand, since the computed temperature T_c is greater than the actual temperature by the amount of heat radiated at the instant of flame formation, the temperature head as determined by computation from this temperature is closer to what actually happens than that determined with T_o as found by measurement to start with.

Before the initial temperature is computed, it is necessary to determine the loss due to the residues of combustion. Thus, if the ashes contain 20 per cent of carbon, equivalent to $0.095/5 = 0.019$ kg., the loss of heat due to this source is equal to $0.019 \times 8100 = 154$ large calories per kg.

In the case of combustion with 50 per cent excess air, the following gases are sent up the smokestack:

$$\left.\begin{aligned} \frac{0.760 - 0.019}{0.536} &= 1.382 \text{ cu. m. } CO_2 \text{ with } 1.382\ O_2 \\ \frac{0.045}{0.09} &= 0.500 \text{ cu. m. } H_2O \text{ with } 0.250\ O_2 \end{aligned}\right\} = 1.632 \text{ cu. m. } O$$

$$\frac{0.040}{0.8} = 0.050 \text{ cu. m. } H_2O$$

$$\frac{0.060}{1.43} = 0.042 \text{ cu. m. } O_2.$$

The minimum oxygen required for combustion $1.632 - 0.042 = 1.590$ cu. m.; add to this 50 per cent excess = 0.795 cu. m., a total of 2.385 cu. m., which carries with it 8.768 cu. m. of nitrogen. The smokestack gases have therefore the following composition: $1.382\ CO_2 + 0.550\ H_2O + 0.795\ O_2 + 8.968\ N_2 = 11.695$ cu. m.

The heat content of these gases is $7456 - 154 = 7302$ large calories per cu. m., and the initial temperature is therefore $T_0 = 7302/11.695\,c$, where c is the specific heat of the smokestack gases. As this latter varies with the temperature it cannot be determined in advance analytically. But for the present case, the curves of Kuzell and Wigton (*Feuerungstechnik*, May 15, 1916, p. 191) give $c = 0.3714$, which gives for T_o the value 1680 deg. cent. The heat transmission per hour is therefore—

$$W = C\,\frac{1680-300}{\log\,(1680-183) - \log\,(300-183)} = 1245\,C.$$

Every fuel of which the thermo-calorimetric heating value has to be determined must satisfy this output per hour.

As regards the specific heats for the gases at 300 deg. cent. tem-

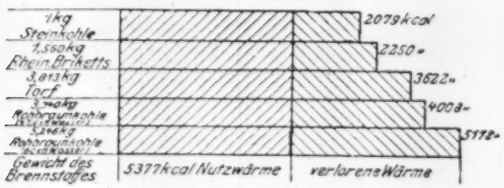

FIG. 1 HEAT BALANCES FOR VARIOUS FUELS

(*First Column, reading down:* 1 kg. coal; 1.560 kg. Rhine briquets; 3.813 kg. peat; 3.340 kg. lignite (47.6 per cent water); 5.246 kg. lignite (60 per cent water); Weight of Fuel. *Second Column:* 5377 large calories, useful heat. *Third Column:* Heat loss. *kcal* = large calories.)

perature, the following holds good. For carbon dioxide, 0.442; for water vapor, 0.376; for oxygen and nitrogen together, 0.318; whence —

$W_R = 300\,(0.442 \times 1.382 + 0.376 \times 0.55 + 0.318 \times 9.783) = 1179$ large calories per kilogram.

Therefore, if we assume that in the boiler-setting walls the heat loss amounts to 10 per cent or 746 large calories, the total useful heat is $7456 - 154 - 746 - 1179 = 5377$ large calories per kilogram, corresponding to an efficiency of 72.1 per cent.

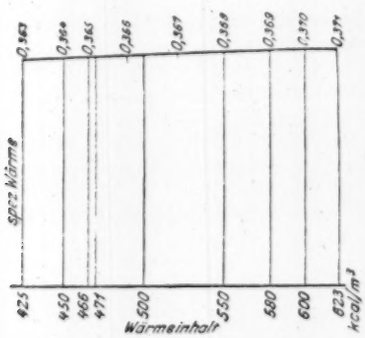

FIG. 2 RELATION BETWEEN HEAT CONTENT AND SPECIFIC HEAT OF SMOKESTACK GASES (*Spezwaerme* = specific heat; *waermeinhalt* = heat content; *kcal/m³* = large calories per cu. m.)

The author carries through the same computation for lignite briquets, two kinds of crude lignite—one with 47.8 and the other with 60 per cent water—and peat. The results are presented in the form of tables and figures. As regards the latter, Fig. 1 is of particular interest as showing the dependence of heat losses on the composition of the fuel and in particular moisture content. From this figure it would appear that whereas the useful heat output remains all the time at the same level of 73.77 large calories, the heat losses rise from 2079 large calories per kilogram in the case of good coal to 5178 large calories per kilogram for crude lignite containing 60 per cent of water. These figures are particularly impressive if we take into consideration their general significance; thus, in order to produce with crude lignite containing 60 per cent water the same amount of useful heat that is produced with 1 kg. of coal, it is necessary to burn on the grate $5^1/_4$ times the weight of the fuel, which means not only increased losses in the fuel itself but also a material increase in the cost of handling the fuel. Furthermore, the high-moisture fuels give a low economy from the point of view of ultimate steam generation, because they produce a lower degree of steam superheat.

The following table gives a comparison between thermo-calorimetric values for the various fuels and calorimetric values, which would indicate the comparatively low reliability of the calorimetric values.

	Thermo-calorimetric heating value	Calorimetric heating value
Good coal	1.000	1.000
Rhine lignite briquets	0.641	0.656
Crude lignite with 47.8 per cent water	0.299	0.377
Peat with 45.5 per cent water	0.262	0.317
Crude lignite with 60 per cent water	0.191	0.270

The higher the moisture content in the fuel the less the information given by the calorimetric heat value; for example, in the case of crude lignite with 60 per cent water, the error as compared with the thermo-calorimetric value is 41 per cent on the wrong side.

For the purpose of simplifying the calculations involved in deriving the thermo-calorimetric heating value of a fuel, the author worked out the two diagrams shown in Figs. 2 and 3. He finds that if in accordance with the above method of calculations, one should plot a diagram in which the heat values per cubic meter of smokestack gases at the initial temperature of each case are plotted as abscissas and the specific heats thereof as ordinates, it will be found, as appears from Fig. 2, that the line connecting these values would be a straight line. Therefore, if one knows the heat content per cubic meter of a gas, one can read off from Fig. 2 the specific heat directly and thus compute T_o.

The curve in Fig. 3 shows the relation between the initial and

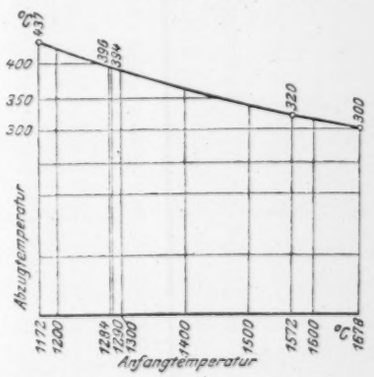

FIG. 3 RELATION BETWEEN INITIAL AND EXHAUST TEMPERATURES OF SMOKESTACK GASES (*Abzugstemperatur* = outlet temperature; *anfangstemperatur* = initial temperature.)

the outlet temperatures in accordance with the method of calculation indicated above, and thus makes it possible to read directly the outlet gas temperature for each initial temperature. (*Zeitschrift des Vereines deutscher Ingenieure*, vol. 66, no. 20, May 20, 1922, pp. 495–497, 3 figs., *t.A*)

Short Abstracts of the Month

AERONAUTICS (See also Internal-Combustion Engineering)

FLOW TESTS ON SLOTTED AEROFOILS. Data of experiments carried out by Lachmann at Goettingen, Germany, of particular interest because, in this case, the behavior of the eddies at various points and at various angles and velocities was shown by means of sal ammoniac smoke, a method which might be applicable in testing fans, blowers and similar apparatus. Two main flasks are used, one containing hydrochloric acid and the other ammonia.

A third flask serves as a reservoir and from it there is a connection with a tube with one or more jets through which the sal ammoniac vapor passes. The two main flasks stand in a bed of water warmed by a Bunsen burner to assist vaporization. The necessary pressure is supplied by a small pump driven by an electric motor. (*Flight*, vol. 14, no. 22/701, June 1, 1922, pp. 315–316, 15 figs., *d*)

AIR MACHINERY

Rotary Air Compressor with Laminated Springless Blades

NEW ROTARY AIR COMPRESSOR, Dr. E. Loewenstein. The new compressor is of the rotary type with springless abutment blades. The housing *A*, Fig. 1 is a hollow cast-iron cylinder with end plates eccentrically held in a bearing. The shaft *B* rotating within carries a cylindrical iron body *C* with three radial slots *D* staggered at 120 deg. In these slots are located movable brass plates interleaved with "Vulkan" fiber laminations *E*, the width of which is equal to the length of the cylinder. On one side the shaft comes out of the cylinder and is held there by a nut. If, now, the shaft *B* and with it the inner cylinder *C* are set into rotation, the brass plates *E* with their fiber laminations are forced by centrifugal force against the walls of the hollow cylinder, providing thereby an airtight joint. Because of the eccentric position of the shaft

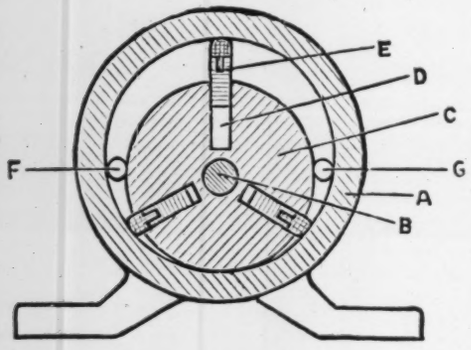

FIG. 1 NEW VALVELESS AIR COMPRESSOR

B, the dimensions of the various air chambers created thereby are non-uniform. On the other hand, the air inlet port *F* and air outlet port *G* are so located that the air always enters at the point where the blades project farthest out of the drum, i.e., where the en-

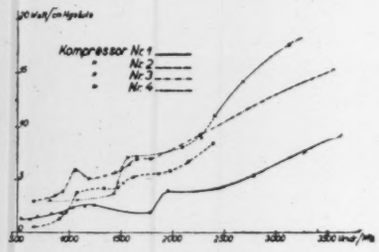

FIG. 2 DATA OF TESTS ON AIR COMPRESSOR SHOWN IN FIG. 1

closed volume is at a maximum. The air thus enclosed is compressed during the further part of the rotation owing to the gradually diminishing size of the chamber and is forced out under an increased pressure through the outlet orifice *G*. It follows from this that the volume of air handled and its pressure depend, according to a straight-line law, on the number of revolutions per unit of time. Should it prove that the joint between the blades and the cylinder walls is absolutely airtight, any pressure or volume can be obtained from this type of pump. In actual construction, however, the power consumption is not proportional to the pressure developed. This is explained by the losses due to the friction of the abutment blades against the cylinder walls.

The results of tests undertaken at the Goettingen Institute for Applied Electricity are shown in Fig. 2, where the abscissas are r.p.m. and ordinates, watts of power consumption per unit of pressure rise expressed in centimeters of mercury. The compressors Nos. 2, 3 and 4 in which the efficiency appeared to be rather low had blades made of brass without fiber laminations. Compressor No. 1 had brass laminations alternating with laminations of Vulkan fiber. Other tests showed the relation between air-gage pressure and speed in revolutions per minute.

The compressor may be built in very small units to be driven by a motor ranging from $^1/_{16}$ to $^1/_6$ hp. (*Deutsche Optische Wochenschrift*, vol. 8, no. 22, May 28, 1922, pp. 413–414, 4 figs., *de*)

ENGINEERING MATERIALS (See also Special Processes)

Fatigue of Metals

FATIGUE OF METALS, C. E. Stromeyer. In a paper read by the author before the Royal Society an empirical law of fatigue was proposed, expressed in the following formula:

$$S = Fl + C\,(10^6/n)^{1/6}$$

where S is the alternating stress which will cause failure after being repeated n times; Fl is the fatigue limit of the material and C is a constant. The original fatigue-testing machine used by the author was unsatisfactory. Recently, however, the Committee of the Manchester Steam Users' Association for the Prevention of Boiler Explosions ordered a larger machine, which permitted the thermometric and elastic determination of the fatigue limits. It was found that these and the calorimetric and extrapolation determinations were in close agreement, so that there are now available three quick and one slow method of determining this very important point. This machine is described in the original article.

It has been found that as soon as the fatigue limit is reached, what may be called molecular friction takes place in the sample which generates heat, and this can be detected either calorimetrically or by means of very sensitive thermocouples and galvanometers; at the same time the elastic properties of the material undergo a change, which can be determined by suitable instruments.

The first question to be settled is whether the fatigue limit is affected by permanent stress, and with this end in view Woehler's tests on wrought iron have been analyzed, as follows: His test results were entered on a diagram and with the modified fatigue law the fatigue limits were estimated by extrapolation. They evidently decreased with increasing permanent stress. The best argument with the experiments is obtained by assuming an ultimate strength estimated not on the original section of the sample but on a reduced section, this stress being therefore higher than the usual accepted ultimate strength. It sounds paradoxical that even for a single fatigue stress the fatigue limit should be higher than the ordinary ultimate strength, but this can happen.

Thus, Woehler tested the wrought-iron sample, which had a tenacity of 21 to 21$^1/_2$ tons per sq. in., yet when he subjected it to alternating stresses ranging from zero to 23 tons it resisted them 800 times.

The following are the results of the author's own tests on mild steel, the only ones which have ever been made for the determination of the fatigue limits of permanently stressed samples. With an average compression stress of 0.46 ton, the fatigue limit was reached with an alternating stress of ±11.4 tons, the range of stress being from 15.86 tons compression to 6.94 tons tension. With no permanent stress the limit was reached with 10.87 alternating stress and with an average tension stress of 4.47 tons the fatigue limit was reached with 9.32 alternating stress, the range being from 4.85 tons compression to 13.79 tons tension. The results when plotted do not lie on a straight line, but suggest a parabolic fatigue curve. The test results obtained are compared with the formula in a table, which shows that the two agree reasonably well. It is evident that as the expression following C in the above formula is large for the case of a single application of stress causing rupture, it would have to be multiplied by a factor $(T-Fl)$, where T is the ultimate stress and Fl is the fatigue limit where the permanent stress is P. When $P=0$, $Fl=Fl_0$. Apparently, T would have to be chosen higher than the ordinary or static tenacity, in order to harmonize the result, and possibly the stress on the contracted, instead of the original, area would have to be taken. It was also assumed that the fatigue limit varied from Fl_0 to $Fl=P$ when $P=T$, and the curve marked fatigue limit was assumed to be a parabola.

The author gives a highly interesting diagram combining many of his results. Woehler, being unable to determine the fatigue limits, could only give the results which are shown in the original in a table and the empirical formula, and had to find this curve by extrapolation. That the fatigue-limit curves are not far from the truth is evident from the fact that the fatigue stresses in the table, which have been estimated with the help of the formula, are in close agreement with the actual stresses. It will also be seen that the ringed crosses in the diagram fall very close to the respective curves or cycle contours.

The arrowheads indicate the positions where this formula would have placed the results. The complete formula is:

$$S = [P + Fl_0 (1 - P^2/T^2) + KTM]/(1 + KM)$$

Here S is the combined permanent stress P, plus the fatigue stress which will cause fracture after n repetitions. Fl_0 is the fatigue limit of the material when there is no permanent stress P. In this case Fl_0 is 7 tons. The enhanced ultimate strength is T, and in this case it appears to be 26 tons. K is a coefficient which in this case is 0.30. M stands for the expression $10^6/n^{1/4}$. Thus, for this sample of iron:

$$S = [P + 7(1 - P^2/676) + 13.8M]/(1 + 0.3M)$$

For no permanent stress we have the region marked "Piston Rods;" it embraces all similar cases like connecting rods, watch springs, etc. The practical working limits of stress seem to be 3 tons for wrought iron, so that here the factor of safety is about $2^1/_2$.

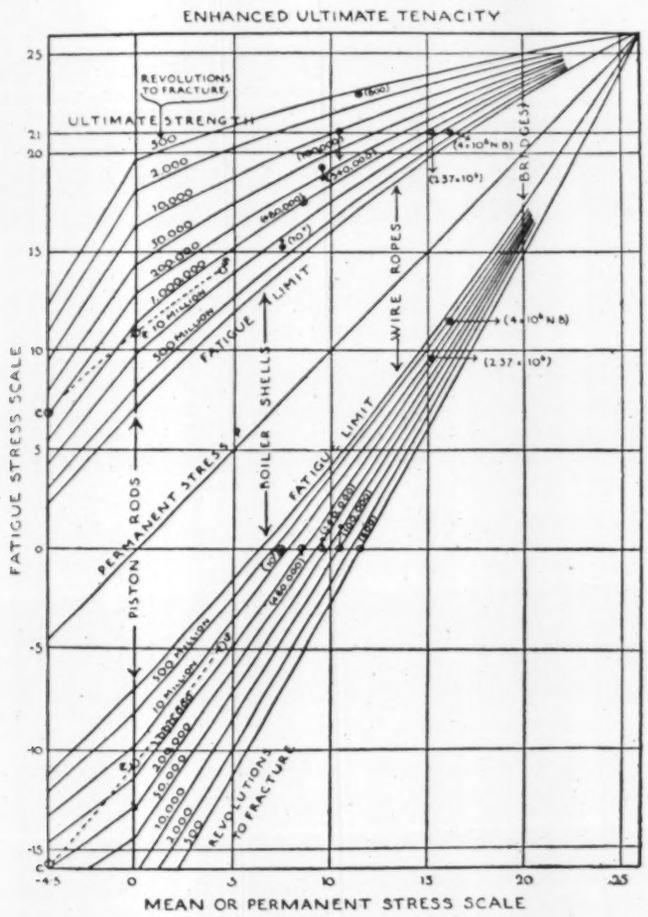

FIG. 3 FATIGUE-LIMIT CURVES

For short objects, where no buckling is possible, higher stresses are allowed. The inner tubes of large guns should occupy a position in the diagram very close to "Piston Rods," for when at rest they are subjected to severe compression stresses, whereas under pressure they are subjected to tension or rather shearing stress. As far as can be ascertained, both these stresses fall outside the fatigue-limit curve, which would mean that the factor of safety of inner gun tubes is less than one. This need cause no alarm: it means that the inner gun barrel will ultimately fail; but, according to the diagram, it will stand a definite number of repetitions of stress. In fact, partly for this reason, partly on account of wear and tear, the inner gun barrels are renewed after a certain number of rounds, say, 2000.

To the left of the "Piston Rods" region is one marked "Boiler Shells." The average stress—in this case it can hardly be called the permanent stress—is half the working stress. When at rest there is no stress; when under pressure the permanent and alternating stresses are added together. According to Fig. 2, the fatigue limit is reached when the combined permanent and alternating stress is about 13 tons. In practice a stress of about $5^1/_4$ tons for wrought iron of 21 tons is considered safe, and explosion stresses do not fall below 8 tons even with heavily corroded shell plates. Here, then, we have a factor of safety of about 2.5, using the fatigue limit as a basis. This comparatively large factor seems to be due to sentiment or fear. It is a justifiable one, for piston rods and connecting rods do occasionally break, their factor of safety being somewhat low, whereas boiler shells never burst at less than 8 tons stress if of iron. No cases are known of acid open-hearth shell failures, but basic-steel failures are frequent on the Continent and in America.

To the left of the "Piston Rods" region, but outside the diagram, would be placed "Boiler Furnaces," because their stresses range from 0 to a maximum compression stress. For long furnaces the factor of safety based on the fatigue limit is about 12. This is due to considerations about buckling and overheating, and the impossibility of insuring perfect circularity of shape. In a recent test, ovality of $^3/_4$ in. in a 36-in. furnace led to collapse when the mean stress was 2.0 tons. The bending stresses were, of course, very severe, the ovality having increased to nearly 3 in. just before collapse took place.

The next region in the diagram is marked "Wire Ropes," but embraces many objects in which the fatigue stresses are not quite as severe as the permanent stresses. This region also embraces the tension members of short bridges, in which the live stresses are relatively very severe.

"Bridges" occupy the extreme right hand of the diagram. Here the permanent stress is very severe and the alternating stress very light. This region differs essentially from that of "Piston Rods" and inner tubes of guns because the range from the fatigue limit to the breaking stress is very narrow, and whereas with guns of wrought iron the fatigue limit may be exceeded by 6 tons with a reasonable certainty that such stresses may be repeated one million times without failure, the diagram shows that the same limited life would be reached in heavy bridges if the fatigue stresses were increased over the fatigue limit by only a fraction of a ton. (Paper read May 25, 1922, before the South Wales Institute of Engineers, abstracted through the *Iron and Coal Trades Review*, vol. 104, no. 2831, June 2, 1922, pp. 822–824, 2 figs., *etA*)

WHITE-METAL AND BRASS BEARING MATERIALS. A general discussion of the subject, with particular reference to German practice. One of the tables gives compositions for white-metal alloys as used by the Prussian and Bavarian State Railways and in commercial practice in England. Data are also presented on aluminum bronzes with 10 per cent aluminum content and also titanium-aluminum bronzes, and a table is given showing the variation in physical properties of these bronzes with their heat treatment. Another table gives the melting points and freezing points of the various lead tank alloys, beginning with 120 lead to 140 parts tin and ending with 240 lead and 150 parts tin. As a good metal for wheel bearings the following composition is recommended: 72.4 parts copper; 4.7 parts tin; 29.9 parts zinc; 0.5 part iron and 1.5 parts lead. (*Zeitschrift fur die gesamte Giessereipraxis*, vol. 43, no. 23, June 10, 1922, pp. 316–317, *g*)

CAUSES OF FAILURE IN CAST-IRON PIPE, F. A. McInnes. Among the causes of failure not sufficiently safeguarded in specifications is the quality of the iron in the pipe. The specifications require the test bars to support a center load of 1900 to 2000 lb. and to show a deflection of 0.3 in. before breaking. The weak point in these requirements lies in the fact that no direct connection is made between the loading and deflection, with the result that in many cases the test bars do not show 0.3 in. deflection until the load is in excess of 1900 or 2000 lb., oftentimes largely in excess. The author shows that of 2183 test bars broken by the Metropolitan Water Board of Massachusetts during the past 9 years less than a half showed the proper deflection at the specified load, which would indicate the use of metal of widely different quality, varying from very hard to very soft. The author objects to establishing a specified composition of the iron, but believes that permissible sulphur content at least should be specified. With this provision, together with a logical relation between flexure and breaking load fixed in the test-bar requirements, a long step forward toward uniform and satisfactory iron will have been taken. (*Engineering and Contracting*, vol. 57, no. 24, June 14. 1922, pp. 563–564, *p*)

IMPROVED NICKEL SILVER. The appearance of stainless steel has called increased attention to the necessity of research in the field of non-ferrous alloys for the purpose of finding those having the same property of "stainlessness."

One such alloy recently developed is an improved form of nickel silver containing a much larger percentage of nickel than does the ordinary alloy. This metal is harder and of a color more nearly approaching that of silver than ordinary nickel silver and costs about one-third less than stainless steel or iron.

Furthermore, the same research has resulted in the production of a more homogeneous metal than formerly, and as this means greater ductility it will now be possible to make deep stampings and pressings from sheets of alloys with a high nickel content. It is stated that spoons and forks made of such alloy can be produced at less than half the cost of such goods made of stainless steel or iron. (*Brass World and Platers' Guide*, vol. 18, no. 6, June, 1922, p. 195, *g*)

FOUNDRY

CAST NICKEL-CHROMIUM ALLOYS, E. F. Lake. Description of melting and casting of three grades of nickel-chromium alloys as practiced by the Hoskins Manufacturing Co. of Detroit. One grade contains 80 per cent nickel and 20 per cent chromium, with only traces of iron; a second grade is composed of 85 per cent nickel and 15 per cent chromium; while a third grade carries 64 per cent nickel, 11 per cent chromium, and 25 per cent iron. Only electric furnaces are used for this purpose, the equipment consisting of one 2-ton arc electric furnace of the Heroult type, two induction electric furnaces and three crucible-type resistance furnaces. The metals used for making these alloys are chromium (free from all impurities except iron), electrolytic nickel, and a small amount of shot nickel; and for the third alloy, 99.7 per cent iron.

Carbon must be kept out of these alloys as it increases their tendency to oxidize at high temperatures; occluded gases are also very bad. One of the reasons for using shot nickel is because it reduces the hydrogen content in electrolytic nickel. Good chrome-nickel alloy can be made without shot nickel when nickel free from hydrogen (Mond) is used.

A melt in the induction furnace generally consists of from 550 to 650 lb. From 325 to 375 lb. of this is usually drawn off into the ladle for each cast. This leaves a heel of from 225 to 275 lb. to start a new melt. In that way each melt can be drawn off in less than two hours, or five melts in nine hours.

The molds have to be very dry. One way of accomplishing this is by a coil of resistance wire dropped into the mold and heated by an electric current. It would appear that the alloy flows freely and does not chill quickly enough to cause cold shuts. Tubes have been cast with 1-in. cores and $^1/_4$ in. of metal around them in lengths as great as 40 in. Considerable trouble was encountered at first, the greatest difficulty being to anchor the long core so that it would not sag or float. These tubes are cast in pairs with no risers. (*The Foundry*, vol. 50, no. 11, June 1, 1922, pp. 452–454, 6 figs., *d*)

FUELS AND FIRING

FROTH-FLOTATION TESTS ON BITUMINOUS COKING COAL, Oliver C. Ralston and Gaichi Yamada. Data of research on applicability of froth flotation to the treatment of the fine size of coals of the Pacific Northwest, carried on by the Northwest Experiment Station of the Bureau of Mines in coöperation with the University of Washington, at Seattle. Only the conclusions of this interesting article can be reported here.

Tests on a bony coking coal from the Wilkeson mine, at Wilkeson, Wash., have shown that the cleanest coal can be floated first, the bony coal next, and the ash last by ordinary froth flotation. Very thin oils or soluble frothing agents work best. The fine sizes of coal float the most easily and the coal in the very fine slime will float to some extent without the use of any flotation oil whatever.

Due to the tendency of fine sizes to float so easily, they are probably "overboiled" and produce dirty concentrate when enough oil is added to float the coarser sizes. Screen analyses of the flotation concentrate show increasing percentages of ash in the finer sizes.

To take due advantage of the above facts, it is necessary to use a flow sheet in which roughing treatment is followed by cleaning of both concentrate and tailing from the roughing cell, discarding as tailing material which will not float in any of the retreating cells. Retreatment of middling with original feed is not desirable except for the middling obtained in cleaning the rough concentrate.

By this method of treatment a clean concentrate can be obtained; the bony portion of the coal forms a middling which may have a market value, and the tailing is too low in coal to be of any value.

Attempts to control the flotation tests by sink-and-float tests with heavy solutions have failed on the fine sizes of coal, due to their supposed porosity. (*Chemical and Metallurgical Engineer*, vol. 26, no. 23, June 7, 1922, pp. 1081–1086, 2 figs., *eA*)

GAS PRODUCERS

Ash Fusion Gas Producers

ASH-FUSION GAS PRODUCER, M. A. Fichet. Description of a type of gas producer in which the temperature is such as to obtain a fused slag. The idea basically is not new and was described by Ebelmen in a paper before the French Academy of Sciences in 1842.

The author also states that he saw in a small forge in Savoy an apparatus of this character which had been in operation for over twenty years. In developing apparatus based on this same principle the author made certain improvements, one of the first being the elimination of the use of steam and hot air and the substitution of cold air. It was found that complete fusion of the ash can be thus obtained, but not with every coal, as it was found that in various coals the fusion point of the ash varied from 1178 to 1500 deg. cent. In addition, it was found desirable to lower the melting point of the ash by the addition of fluxes, so as to produce a slag containing the silicates of several bases, alumina, lime, magnesia and the oxides of iron and other metals. The composition of this slag was found to resemble that of common glass.

Ashes of this composition when heated to proper high temperatures first soften, and then are converted into a pasty condition and finally melt. In softening, the material becomes sticky and has the tendency to agglomerate and form an impermeable mass with the fuel, preventing the passage of the gas through it. Furthermore this pasty mass tends to stick to the walls of the producer. In the pasty state of fusion the half-melted materials can surround the particles of fuel and subject them to the oxidizing action of the air. There are two dangers that must be avoided at this point. If the material sticks to the hot walls of the crucible, then the coal can no longer be fed into the crucible in a regular manner; if the cooled mass becomes covered over with a skin, then the regular course of the combustion is interrupted, the temperature decreases, the mass solidifies and it becomes necessary to break up the congealed mass with a pick, which is a very troublesome procedure.

It is for the purpose of avoiding this double danger that steam is introduced at the base of the boshes. When the water vapor comes into contact with the incandescent carbon it is decomposed, with the production of water gas. As this reaction absorbs a considerable quantity of heat, a sudden decrease in the temperature takes place, which allows the fulfillment of the condition that the high temperature of the crucible should not reach into the boshes.

There are therefore three successive stages in the gasification of the coal in this apparatus:

1 In the crucible—the production of producer gas, with fusion of the ash
2 In the boshes—drop of the temperature, with the production of water gas
3 In the shaft—distillation of the coal, with the production of illuminating gas.

In the case where coke is used as the fuel, the last step does not exist. The proportion of illuminating gas in the final mixture depends on the nature of the coal, i.e., whether it is high in volatile matter or not.

The gas produced from coke containing 15 per cent of ash had the following composition: carbon monoxide, 41.62 per cent; hydrogen, 1.08 per cent; carbon dioxide, 1.75 per cent; nitrogen,

55.55 per cent. Every kilogram of the coke gave 4644 kg. [this figure is obviously an error; perhaps, 4.644 cu. m. is meant] of gas, which had an average calorific power of 6100 cal. Such a product was obtained with the use of an air blast at a temperature of 300 deg. cent. and the injection of steam at a point above the lower end of the boshes.

In order to obtain the effective heat value of the gas leaving the gas producer, it is necessary to add the 998 cal., in the gas at the temperature of 760 deg. cent. to the above value of 6100 cal. On the other hand it is necessary to subtract 230 cal. carried out in the hot air leaving the gas producer at a temperature of 300 deg. cent., and the 293 cal. carried out in the steam. This leaves a final net value of 6554 cal. as the true heating value of the gas.

The thermal efficiency of the process is therefore 6554 cal. divided by 6868 cal., or 95.5 per cent. The 6868 cal. represent the heating value of 850 grams of carbon in 1000 grams of coal after the deduction of 150 grams of ash.

It is claimed that in gas producers operating with fusion of ash it is possible to build units capable of gasifying 2500 kg. (5500 lb.) of fuel per hr., and in addition it is possible to utilize coals of very poor quality. Thus, coke containing as much as 40 per cent ash can still be used in this apparatus and give gas of good quality.

There are now several types of gas producers which gasify coal with fusion of the ash. Among these the Rehmann producer is of particular interest because of its novel construction. This is a German invention and is shown in Fig. 4. The crucible is shown at *a*, the boshes at *b* and the shaft at *c*. A hole *h* is also provided for introducing a tool for raking the coal. The apparatus is a large one. The diameter of the crucible is 2 m., that at the center of the shaft 3.6 m. The producer is furnished with air and

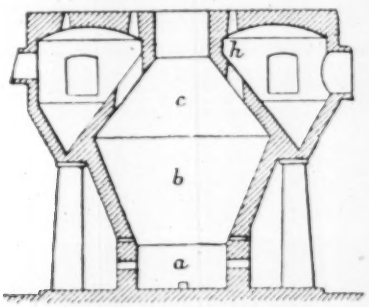

FIG. 4 REHMANN ASH-FUSION GAS PRODUCER

steam tuyeres. The shaft is surrounded with an annular chamber which is used to catch the dust that may be present in the gas. The cross-sectional area of this chamber is quite large, so that the gas passes through less rapidly. A valve is provided at the side of the chamber to release the pressure in case of an explosion.

While it is not certain that this apparatus has been used practically, it represents a distinct advance in design and indicates the interest that is being shown in this type of gas producer. The many advantages that it offers, the simplicity of construction, the ease of operation, the good quality of gas produced, the efficiency of the gasification, the low initial cost, all are said to tend to point to the ash-fusion producer as the logical gas producer of the future. (*American Gas Journal*, vol. 116, no. 24, June 17, 1922, pp. 550–552, 2 figs., *d*)

HYDRAULIC ENGINEERING

The Hydrautomat

THE HYDRAUTOMAT. Description of a new and simple device by which a low fall may be transformed under certain restrictions into a high fall, or water can be lifted to a considerable height without the use of rotary or reciprocating pumps. The device essentially consists of a series of tanks connected by piping in proper ways.

The principle of the device is illustrated in Fig. 5. If we deliver water under a head into the bottom of a closed chamber *A*, the air in that chamber will escape upward if it possibly can. An air-vent pipe is therefore provided connected also to the top of another closed chamber *B* which is supposed to be full of water. Then if the air enters at the top of *B* it will exert pressure on the upper surface of the water. If there is a pipe from the bottom of the upper tank *B* to a still higher tank *C*, the water will be delivered into tank *C* provided the vertical distance is within limits. Now, assume that the process is reversed and that if water is discharged into *A*, the lowest tank of the three, it shall fall through a discharge pipe to the ground. A partial vacuum is thus caused at the top of the tank *A*, hence, also in the second or intermediate tank *B*. Evidently, if we throw open a valve which allows tank *B* to suck

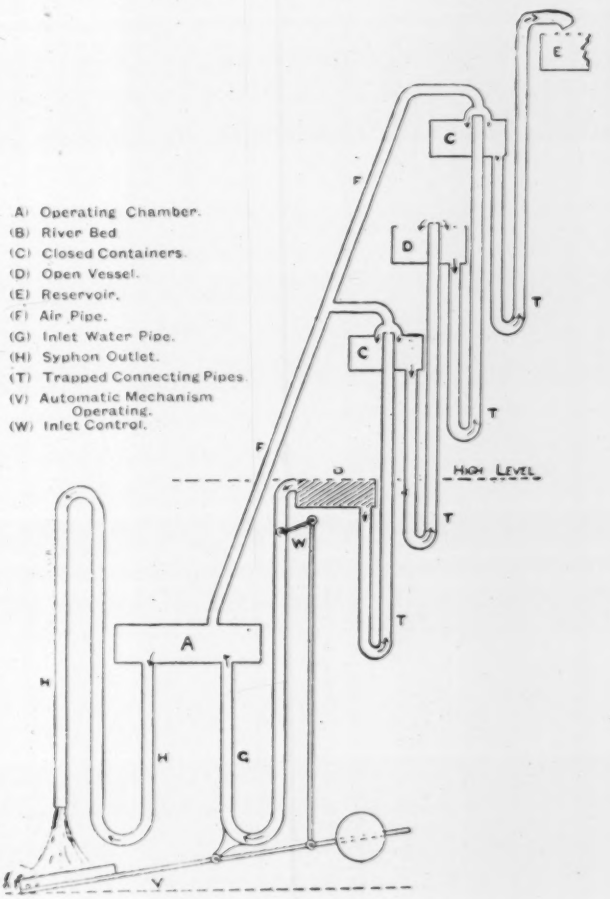

FIG. 5 DIAGRAM SHOWING THE GENERAL PRINCIPLE OF THE ALLEN HYDRAUTOMAT

up water from below, it will replenish itself with liquid to replace the outgoing air. Here atmospheric pressure is used and a column of air acts to some extent as the piston of a pump. This combination of atmospheric pressure with the pressure of water is what constitutes the novel principle of the hydrautomat. The inventor, T. G. Allen, uses compressed air for his forcing stroke, obtaining the compression by falling water and a partial vacuum for his suction stroke, this vacuum also due to falling water.

The cycle of the hydrautomat is as follows:

Pressure Stroke. This is caused by the weight of the water column, which flows into the closed chamber *A* at low level from the head race; this incoming water compresses the air in this closed chamber, and forces it out along the air-conducting pipe, whence it enters an overhead closed tank (or tanks). The effect is that the water in the overhead tank *C* is, in its turn, forced out and pushed up into a still higher tank *D*. This is an open one. One complete flight of the ascent is thus accomplished. At the end of this pressure stroke the closed operating chamber *A* at low level and the open tank *D* are full of water, but the overhead closed tank *C* is full of air.

Suction Stroke. This is governed entirely by atmospheric pressure. The contents of the closed chamber *A* at low level are drawn down, and discharged into the tail race. Simultaneously the inlet from the head race is automatically closed. The closed operating chamber then begins to feel a vacuum, and this vacuum extends

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Tests on a bony coking coal from the Wilkeson mine, at Wilkeson, Wash., have shown that the cleanest coal can be floated first, the bony coal next, and the ash last by ordinary froth flotation. Very thin oils or soluble frothing agents work best. The fine sizes of coal float the most easily and the coal in the very fine slime will float to some extent without the use of any flotation oil whatever.

Due to the tendency of fine sizes to float so easily, they are probably "overboiled" and produce dirty concentrate when enough oil is added to float the coarser sizes. Screen analyses of the flotation concentrate show increasing percentages of ash in the finer sizes.

To take due advantage of the above facts, it is necessary to use a flow sheet in which roughing treatment is followed by cleaning of both concentrate and tailing from the roughing cell, discarding as tailing material which will not float in any of the retreating cells. Retreatment of middling with original feed is not desirable except for the middling obtained in cleaning the rough concentrate.

By this method of treatment a clean concentrate can be obtained; the bony portion of the coal forms a middling which may have a market value, and the tailing is too low in coal to be of any value.

Attempts to control the flotation tests by sink-and-float tests with heavy solutions have failed on the fine sizes of coal, due to their supposed porosity. (*Chemical and Metallurgical Engineer*, vol. 26, no. 23, June 7, 1922, pp. 1081–1086, 2 figs., *eA*)

GAS PRODUCERS

Ash Fusion Gas Producers

ASH-FUSION GAS PRODUCER, M. A. Fichet. Description of a type of gas producer in which the temperature is such as to obtain a fused slag. The idea basically is not new and was described by Ebelmen in a paper before the French Academy of Sciences in 1842.

The author also states that he saw in a small forge in Savoy an apparatus of this character which had been in operation for over twenty years. In developing apparatus based on this same principle the author made certain improvements, one of the first being the elimination of the use of steam and hot air and the substitution of cold air. It was found that complete fusion of the ash can be thus obtained, but not with every coal, as it was found that in various coals the fusion point of the ash varied from 1178 to 1500 deg. cent. In addition, it was found desirable to lower the melting point of the ash by the addition of fluxes, so as to produce a slag containing the silicates of several bases, alumina, lime, magnesia and the oxides of iron and other metals. The composition of this slag was found to resemble that of common glass.

Ashes of this composition when heated to proper high temperatures first soften, and then are converted into a pasty condition and finally melt. In softening, the material becomes sticky and has the tendency to agglomerate and form an impermeable mass with the fuel, preventing the passage of the gas through it. Furthermore this pasty mass tends to stick to the walls of the producer. In the pasty state of fusion the half-melted materials can surround the particles of fuel and subject them to the oxidizing action of the air. There are two dangers that must be avoided at this point. If the material sticks to the hot walls of the crucible, then the coal can no longer be fed into the crucible in a regular manner; if the cooled mass becomes covered over with a skin, then the regular course of the combustion is interrupted, the temperature decreases, the mass solidifies and it becomes necessary to break up the congealed mass with a pick, which is a very troublesome procedure.

It is for the purpose of avoiding this double danger that steam is introduced at the base of the boshes. When the water vapor comes into contact with the incandescent carbon it is decomposed, with the production of water gas. As this reaction absorbs a considerable quantity of heat, a sudden decrease in the temperature takes place, which allows the fulfillment of the condition that the high temperature of the crucible should not reach into the boshes.

There are therefore three successive stages in the gasification of the coal in this apparatus:

1 In the crucible—the production of producer gas, with fusion of the ash
2 In the boshes—drop of the temperature, with the production of water gas
3 In the shaft—distillation of the coal, with the production of illuminating gas.

In the case where coke is used as the fuel, the last step does not exist. The proportion of illuminating gas in the final mixture depends on the nature of the coal, i.e., whether it is high in volatile matter or not.

The gas produced from coke containing 15 per cent of ash had the following composition: carbon monoxide, 41.62 per cent; hydrogen, 1.08 per cent; carbon dioxide, 1.75 per cent; nitrogen,

55.55 per cent. Every kilogram of the coke gave 4644 kg. [this figure is obviously an error; perhaps, 4.644 cu. m. is meant] of gas, which had an average calorific power of 6100 cal. Such a product was obtained with the use of an air blast at a temperature of 300 deg. cent. and the injection of steam at a point above the lower end of the boshes.

In order to obtain the effective heat value of the gas leaving the gas producer, it is necessary to add the 998 cal., in the gas at the temperature of 760 deg. cent. to the above value of 6100 cal. On the other hand it is necessary to subtract 230 cal. carried out in the hot air leaving the gas producer at a temperature of 300 deg. cent., and the 293 cal. carried out in the steam. This leaves a final net value of 6554 cal. as the true heating value of the gas.

The thermal efficiency of the process is therefore 6554 cal. divided by 6868 cal., or 95.5 per cent. The 6868 cal. represent the heating value of 850 grams of carbon in 1000 grams of coal after the deduction of 150 grams of ash.

It is claimed that in gas producers operating with fusion of ash it is possible to build units capable of gasifying 2500 kg. (5500 lb.) of fuel per hr., and in addition it is possible to utilize coals of very poor quality. Thus, coke containing as much as 40 per cent ash can still be used in this apparatus and give gas of good quality.

There are now several types of gas producers which gasify coal with fusion of the ash. Among these the Rehmann producer is of particular interest because of its novel construction. This is a German invention and is shown in Fig. 4. The crucible is shown at *a*, the boshes at *b* and the shaft at *c*. A hole *h* is also provided for introducing a tool for raking the coal. The apparatus is a large one. The diameter of the crucible is 2 m., that at the center of the shaft 3.6 m. The producer is furnished with air and

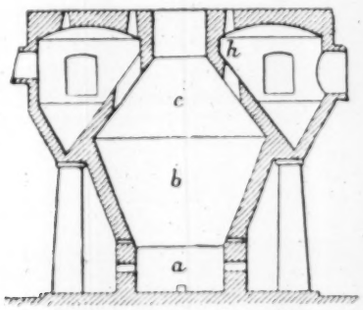

FIG. 4 REHMANN ASH-FUSION GAS PRODUCER

steam tuyeres. The shaft is surrounded with an annular chamber which is used to catch the dust that may be present in the gas. The cross-sectional area of this chamber is quite large, so that the gas passes through less rapidly. A valve is provided at the side of the chamber to release the pressure in case of an explosion.

While it is not certain that this apparatus has been used practically, it represents a distinct advance in design and indicates the interest that is being shown in this type of gas producer. The many advantages that it offers, the simplicity of construction, the ease of operation, the good quality of gas produced, the efficiency of the gasification, the low initial cost, all are said to tend to point to the ash-fusion producer as the logical gas producer of the future. (*American Gas Journal*, vol. 116, no. 24, June 17, 1922, pp. 550–552, 2 figs., *d*)

HYDRAULIC ENGINEERING

The Hydrautomat

THE HYDRAUTOMAT. Description of a new and simple device by which a low fall may be transformed under certain restrictions into a high fall, or water can be lifted to a considerable height without the use of rotary or reciprocating pumps. The device essentially consists of a series of tanks connected by piping in proper ways.

The principle of the device is illustrated in Fig. 5. If we deliver water under a head into the bottom of a closed chamber *A*, the air in that chamber will escape upward if it possibly can. An air-vent pipe is therefore provided connected also to the top of another closed chamber *B* which is supposed to be full of water. Then if the air enters at the top of *B* it will exert pressure on the upper surface of the water. If there is a pipe from the bottom of the upper tank *B* to a still higher tank *C*, the water will be delivered into tank *C* provided the vertical distance is within limits. Now, assume that the process is reversed and that if water is discharged into *A*, the lowest tank of the three, it shall fall through a discharge pipe to the ground. A partial vacuum is thus caused at the top of the tank *A*, hence, also in the second or intermediate tank *B*. Evidently, if we throw open a valve which allows tank *B* to suck

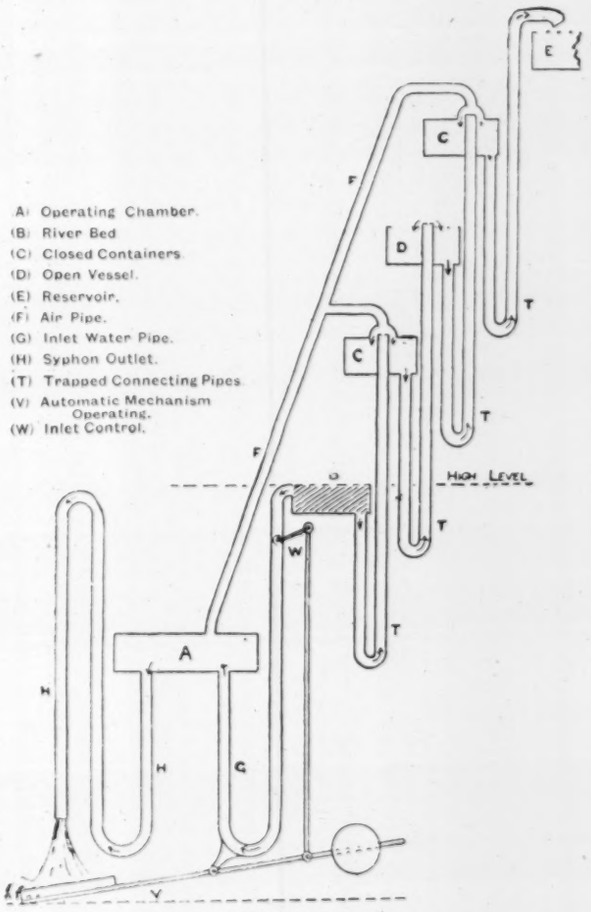

FIG. 5 DIAGRAM SHOWING THE GENERAL PRINCIPLE OF THE ALLEN HYDRAUTOMAT

up water from below, it will replenish itself with liquid to replace the outgoing air. Here atmospheric pressure is used and a column of air acts to some extent as the piston of a pump. This combination of atmospheric pressure with the pressure of water is what constitutes the novel principle of the hydrautomat. The inventor, T. G. Allen, uses compressed air for his forcing stroke, obtaining the compression by falling water and a partial vacuum for his suction stroke, this vacuum also due to falling water.

The cycle of the hydrautomat is as follows:

Pressure Stroke. This is caused by the weight of the water column, which flows into the closed chamber *A* at low level from the head race; this incoming water compresses the air in this closed chamber, and forces it out along the air-conducting pipe, whence it enters an overhead closed tank (or tanks). The effect is that the water in the overhead tank *C* is, in its turn, forced out and pushed up into a still higher tank *D*. This is an open one. One complete flight of the ascent is thus accomplished. At the end of this pressure stroke the closed operating chamber *A* at low level and the open tank *D* are full of water, but the overhead closed tank *C* is full of air.

Suction Stroke. This is governed entirely by atmospheric pressure. The contents of the closed chamber *A* at low level are drawn down, and discharged into the tail race. Simultaneously the inlet from the head race is automatically closed. The closed operating chamber then begins to feel a vacuum, and this vacuum extends

to all the other higher closed tanks through the medium of the air-conducting pipe. In consequence, the water in each open tank (these being now full) is sucked up one flight into the next higher closed tank. At the end of this suction stroke the operating chamber and open tanks are empty and the closed tanks are full of water. The inlet from the head race is then automatically opened, pressure water is admitted, and the pressure stroke is recommenced.

The pipes between the tanks are all water sealed, so that all non-return valves or mechanical checks are dispensed with. The apparatus has no moving parts other than an opening and shutting sluice gate. It is entirely self-contained, and provides its own motive power. The operation is continuous. The contrivance requires no housing, attention, or supervision. There is nothing which can wear out or lose adjustment. It may be constructed from timber, steel or concrete; in fact, from any material which can be made watertight, or practically so.

The inventor claims for his device an efficiency of 80 per cent. It should be clearly understood, of course, that only part of the falling water is lifted to a greater height and the proportion of water lifted is dependent on the height, so that, for example, if we have one gallon a second falling 3 ft. over a sill, this can be converted into 8 gal. per sec. falling through 30 ft. It is expected that this device might be extensively used for purposes of irrigation. (*The Electrical Times*, vol. 61, no. 1600, June 15, 1922, pp. 573–574, 2 figs., *d*A)

INTERNAL-COMBUSTION ENGINEERING (See also Railroad Engineering)

Siemens-Halske 60-Hp. Five-Cylinder Radial Air-Cooled Engine. Under the Versailles Treaty Germany is limited to the use of engines not exceeding 60 hp. for single-seater civilian aeroplanes for the next two years. Because of this limitation of power, one may look forward to see considerable progress made in the efficiency of German aircraft. Since the Germans, if they wish to fly at all, will have to make such improvements in aircraft as will enable them to do the work with the limited power permitted.

The new Siemens-Halske engine comes within the permissible limits of power. No figures as to weight, revolutions, fuel consumption, etc., are available. It is known that the engine has five cylinders and is of the four-stroke type with two valves to each cylinder. The bore is 100 mm. and the stroke 120 mm. The cylinders are of steel with aluminum jackets having fins machined on them for cooling and the pistons are of aluminum or aluminum alloy.

The inlet valve is operated by double rockers actuated by a push rod from the cam gear on the front of the engine. The exhaust valve is operated also through push rods by a single rocker arm placed between the two rockers of the inlet valve. All rocker arms are carried in ball bearings.

The valve-stem guide of the exhaust valve is situated inside a tubular T-piece, so that the exhaust gases escape through two openings. It is believed that the manufacturers have designed a standard exhaust-ring collector for this engine, so that from each exhaust-valve cage, two short L-pipes run to the exhaust ring, which is placed behind the cylinders and from which a single exhaust pipe projects upward. In the standard form the engine is provided with one magneto and one spark plug per cylinder, but dual ignition may be installed. (*Flight*, vol. 14, no. 23/702, June 8, 1922, pp. 326–327, 3 figs., *d*)

MACHINE PARTS

Autopitch Gear

Autopitch Gear. Description of a new gear proceeded by a brief historical discussion on gearing in general.

In starting on his work the inventor of the autopitch gear, W. Rus Darling, compiled the following list indicating the requirements of a perfect gear: (1) Strength sufficient to insure safety; (2) durability unlimited; (3) adaptability to all possible variation of conditions; (4) elasticity sufficient to absorb unavoidable vibrations of other parts; (5) noiselessness approaching to silence; (6) economy both in cost of production and in power. Of this list the third requirement appears to be the most difficult to fulfill, the others being within the scope of modern knowledge and practice.

In considering various types of gears, the author came to the conclusion that the old mill wheel with its continuous stream of water "gearing" into it, adapts itself to almost any conceivable variation of a nature corresponding with those to be met with in mechanical gears. If the mill stream could be rolled up into a circle of a suitable diameter and provided with a shaft and bearings, it would form a pinion of the required adaptability. Machine-cut teeth are not always correctly shaped. The bearing between opposing teeth may be only at a point, or points, instead of on a line the full width of the wheel. But even this line contact when acquired is not a mechanical ideal. Teeth slide as well as roll and concentrated pressure and friction are therefore of great importance, and it is only the high quality of the material available that enables thousands of horsepower to be transmitted through one, two or three lines of contact of 1-, 2-, or 3-ft. lengths.

The oil film plays an important part. If this volume of oil is actually constant it must be concluded that the pressure, the wear, and the transmission are all effected through its medium. It is estimated that in modern high-speed gears the period of contact is about one one-thousandth of a second, and from that fact is deduced the retention of the oil film.

From the foregoing it may be reasoned that the thicker the film the better, and to carry this reasoning to its logical end, if the teeth of one wheel were eliminated and only the oil left, the theory of the endless mill stream would be realized in practice. While

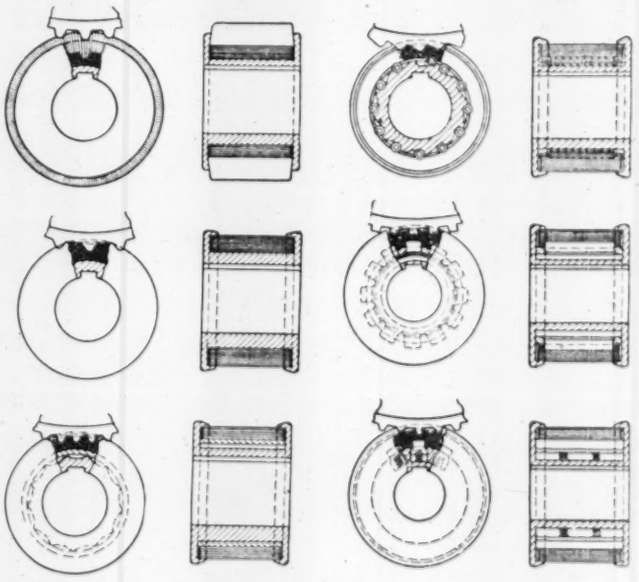

Fig. 6 Autopitch Gear

this cannot be actually done, the question is how near can one get to a continuous oil film.

Reverting to the rational forms and materials of gear teeth, it is found that the finer the pitch, the closer together and therefore more nearly continuous become the successive films of oil. But if the teeth are made too fine to carry the load, all the advantage is lost. It must be concluded, therefore, that for the present, at least, the continuous film is impossible in practice. On the other hand, however, there is an element which is neither a fluid nor a solid and yet possesses something in the nature of both. The only familiar form of it is found in balls. If a number of balls are poured into a vessel, they will find a common level; if run out on a table, they will behave much like water. Rollers behave somewhat similarly but can only flow in two opposite directions, and it is this limitation that enables them to be harnessed in the form of an endless mill stream within the compass of an ordinary pinion as indicated in Fig. 6. This illustration shows how this "semi-fluid" can be controlled and kept in its appointed place. The density of the element may be varied by having more or fewer rollers in a given space; each roller being supported by all the others their individual diameter does not materially affect their strength as a combination, which, in fact, forms one solid "fluid" tooth equal in thickness to almost the circumference of the pinion.

Reverting to the "absurd" proposition of a continuous oil film, it may be seen how nearly approach has been made to its realization. It is at once apparent that each roller provides a line of contact with the engaging wheel tooth, so that, instead of one line of contact per tooth, there is a number varying with the depth of gear mesh. Further, each roller has a film of oil over its entire length and circumference, therefore there is actually that continuous oil film which was previously thought absurd. Not only that, the metal-roller element upon which the film is built is almost as fluid as the oil itself.

The pinion of the construction shown is able to accommodate itself to any straight tooth in a wheel and will continue to do so until the tooth is entirely worn away. It is therefore independent of the contour and thickness of the tooth; also the teeth may engage with it at any point of its circumference and the engagement is thus independent of pitch. This eliminates the necessity of having the teeth geometrically designed and also indicates that irregularity of pitch and missing teeth will not interfere with smooth and continuous running. Further, there are no tooth clearances and therefore no backlash. Other irregularities are provided for in the fact that the rollers are free to incline in either direction across the face. The alignment may be faulty, parts may expand or contract, the foundations may warp and twist without materially affecting the gear. (Paper read before the Institution of Engineers and Shipbuilders in Scotland, abstracted through *Engineering Production*, vol. 4, no. 88, June 8, 1922, pp. 545–548, 24 figs., *dA*)

MACHINE SHOP

GRINDING-WHEEL BREAKAGE AND ITS CAUSES, Harold E. Jenks. A general discussion of the causes producing stresses that result in wheel breakage. The author lists eleven primary causes that may produce the breakage of a grinding wheel while in operation. Among these, particular mention may be made of overspeeding and heating of the wheel. As regards overspeeding, the author states that reliable grinding-wheel manufacturers test all wheels before they leave the factory by running them at a speed approximately twice that for which they are designed and recommended, thus obtaining a factor of safety of about four, and because of this breakages due to speed are few in number. They occur occasionally from such causes as shifting thoughtlessly from large to small pulleys, placing wheels of large diameter on spindles running at speeds intended for smaller diameter, or substituting for a wheel running at the correct speed, one of different grain and grade designed for lower wheel speeds. In other words, most of the breakages due to overspeeding are really due either to carelessness or ignorance on the part of the operator.

As regards heating of the wheel, the author states that stresses due to this cause and produced by the unequal expansion of different parts of the wheel may account for many breakages. Stresses produced through excessive heating of the wheel are similar in character to those produced by centrifugal force and are of two kinds, radial and tangential. The greatest tensile stress is apt to occur at the circumference of the hole and hence combines at that point with the maximum tensile stress due to the centrifugal force. This is important as both these stresses may be large and their resultant may easily cause breakage.

A few years ago the writer assisted in making some tests of the effect of heat alone upon grinding wheels. An electric heating coil was arranged to cover the entire surface of the face of the wheel to be tested, and heat was gradually applied. The wheel was not in motion, so that the effect could be due only to heat. At a temperature of the circumference averaging from 70 to 115 deg. cent., the wheels tested cracked along the diametral plane, some with sufficient force to entirely separate the two halves of the wheel. With the heat thus applied, from 40 to 70 min. elapsed before breakage occurred. It should be borne in mind that the stress due to centrifugal force was not present in these tests, so that it is reasonable to conclude that under similar heating conditions a wheel of the same type in operation would break at a still lower temperature and probably in a shorter time. Actual heat breakages in operation are in very close agreement with this condition.

As stated above, the typical heat break is a diametral crack, the same as in the case of breakage due to centrifugal force. It is evident that a fracture resulting from a combination of heat and speed stresses would be of the same type.

Tight or insufficiently lubricated bearings on a grinding machine may cause heating of the spindle wheel. In case the wheel bushing fits the spindle tightly, the expansion of the latter may cause tensile stresses of considerable magnitude in the wheel. This is clearly the case of a thick cylinder under internal pressure. The stresses produced are similar in character to both those due to centrifugal force and those due to heating of the wheel. They are of two kinds, radial and tangential, as in those cases, and the maximum tangential tensile stress occurs at the circumference of the hole. Hence the maximum stresses would combine at that point and breakage might occur from the resultant stress. The typical break due to heating of the wheel spindle would be a diametral crack, as in the case of breakage due to centrifugal force. (*American Machinist*, vol. 57, no. 3, July 20, 1922, pp. 98–100, 3 figs., *pe*; serial article)

MACHINE TOOLS (See also Machine Shop)

Electrodepositing Iron on Steel

"PUTTING ON" TOOL FOR STEEL PARTS, David R. Kellogg. Description of apparatus and process for electrodepositing iron on steel. The process is a development of the method first described by Thomas and used in the British Army repair shops and also in commercial work. The solution used by Thomas consisted of 75 grams of crystallized ferrous ammonium sulphate per liter of water and was used cold at low current density, namely, 0.33 ampere per sq. dm. Under these conditions the deposit was smooth, bright and adherent, and withstood bending and chipping.

The extensive series of tests undertaken at the Westinghouse Research Laboratory made it possible to lay down a fairly definite set of rules of procedure, by following which one could be sure of a good coating. After most of the grease had been removed from the piece to be coated, and the portions on which no deposit was desired had been covered with a mixture of 90 per cent hydroline (M.P. 100 deg. cent.) and 10 per cent paraffin, it was made the cathode for three minutes in a 10 per cent solution of commercial lye and sal soda in equal proportions. From three to five amperes per square inch were used in this portion of the cleaning—the exact figure, as well as the exact concentration of the solution, being, according to the original article, of no moment. The piece was then washed in running water and made the anode for an equal time in 30 per cent commercial sulphuric acid, using about the same current density. In the acid-cleaning bath it is important to have the current density sufficiently high so that the iron becomes passive and gasses freely. If too low a current density is used, the piece is attacked by the acid and cleaning does not take place. With sufficient current to produce passivity, as indicated by free gassing of the work, the piece comes from the acid-cleaning bath with a beautiful pearly luster, and upon washing in running water and transferring to the plating bath without touching in any way the cleared portion or allowing it to dry, a satisfactory coating is obtained. While the work is in the acid-cleaning bath, any motion of the work will sometimes result in a decrease in current and cessation of gassing of the work, showing that it has become active, i.e., is being attacked by the acid. When this tendency is very pronounced it is an indication that the current density is too low. After cleaning in this manner and transferring immediately to the plating bath, it was found possible to produce satisfactory coatings at the rate of 0.0059 in. per hr., corresponding to a current density of 1 ampere per sq. dm., which is three times the rate attained by Thomas.

This process gave smooth, tough, adherent coats which, when deposited on a carefully ground rod 0.485 in. in diameter and then ground to a thickness of 0.001 in. (0.025 mm.), could be pressed through a hole in 1-in. cold-rolled steel 0.0005 in. smaller than the finished size of the rod, and then pressed back again with no signs of stripping. These test rods could be bent and mishandled in various ways with no damage to the coat.

A motor shaft having bearings 0.625 in. in diameter by 1.5 in. long was purposely finished 0.002 in. small in diameter, plated oversize, reground on proper dimensions, and then assembled

and run in bronze bearings for 1000 hr. with a load of 50 lb. per sq. in. of projected area, using a short stiff belt with a clipper joint in order to give a pounding effect as well as friction. At the end of the run it was found that the wear was 0.0002 in., which is just a trifle less than the original material shows in factory life tests. Plug and thread gages have been repaired by this means and have given good satisfaction, although they are not as hard as heat-treated tool steel.

Next, experiments were made with hot concentrated bath and stirring, the solution used being 300 grams of ferrous ammonium sulphate per liter. The deposits obtained with useful current densities up to 10 amperes per sq. dm. were softer than those from the cold bath, perfectly adherent and of a velvety appearance. This method gave a greater increase in the rate of deposit than corresponded to the increase in current density.

One of the uses suggested for the deposition on cast iron is in giving cast-iron bearing shells a preliminary coating of pure iron so that they may be tinned and the babbitt made to adhere directly to the shell as in the case of bronze shells. This would do away with the necessity for the anchor holes and enable the use of a layer of babbitt about one-third as thick as that used in cast-iron shells with anchor holes.

Attempts to produce a coating while the work was revolving in a horizontal position did not succeed. On the other hand, numerous tests on the working qualities of deposits produced by the successful methods proved the high quality of the material of the coatings and their perfect adherence. While there are several methods of producing good-looking deposits, such deposits for all their good looks may prove to be hard, brittle and lacking in adherence. It seems that only by bending, hammering and cutting can a satisfactory test of working qualities be obtained. (*The Electric Journal*, vol. 19, no. 6, June, 1922, pp. 249–251, *ep*)

Tool for Turning Down Nuts. Description of an electric tool designed for turning down nuts, cap screws, wood screws, and similar fastenings, and arranged to operate in either direction. The machine may be made either stationary or portable. The novel feature is the driving mechanism of the tool, which incorporates a multiple-disk slip clutch, adjustable for any tension within the capacity of the motor and operating through a spline shaft to a positive clutch. The arrangement is such that the positive clutch automatically disengages when the disk clutch fully releases, thus relieving the driving spline from torque. This permits the removing of the wrench, chuck or screwdriver from the driven member and their engagement with the new nut or stud while the motor is running at full speed. The motor can be overloaded or burned out, as the clutch can be tightened to a degree that will stall the motor. The speed of the driving spindle of the machine is variable and during the actual setting-up operation is only about one-third of the speed prevailing while the nut or screw is being driven down. The motor can be reversed by means of a special reversing control mechanism. (*The Iron Age*, vol. 110, no. 3, July 20, 1922, p. 146, 3 figs., *d*)

MARINE ENGINEERING (See Power-Plant Engineering)

METALLURGY (See Special Processes)

New Process for Mechanical Puddling. Description of an installation and process in an American plant (Titan Iron & Steel Co., Newark, N. J.). The principle of the process, which is the invention of Henry D. Hibbard, is in producing an intimate mixture of molten iron and oxide of iron by making the charge of the mixture pour repeatedly over a dam in a thin stream in an oscillating furnace.

The melting stage is carried on in a cupola from which the molten iron goes into the puddling furnace, where the operations of purifying, boiling and balling follow mechanically the hand method. Essentially, the furnace consists of a cylinder of steel plate about 6 ft. in diameter and 5 ft. 6 in. long with projecting trunnions 18 in. in diameter. The cylinder is lined with magnesite brick to an inside diameter of about 4 ft. The dam, which consists also of magnesite brick, extends up nearly to the center line. The operation is carried on at a temperature of about 2650 deg. fahr., the flame temperature (oil fuel) being 2850 deg.

As soon as the iron begins to form into a ball, the oscillating motion of the furnace is stopped and it is rotated clear over. The ball is carried to a squeezer, where it goes down through a passage of continuously decreasing dimensions and thence it is expelled in rough cylindrical form at the far side, free from surface slag and prepared for the breaking-down rolls. The iron is used largely for pipe and sockets, engine bolts, staybolts and high-grade merchant bars. Its physical properties are reported to vary in tensile strength from 45,000 to 52,000 lb.; elongation, 15 to 30 per cent. The original article gives some photomicrographs of mechanically puddled iron and a view of the installation. (*The Iron Age*, vol. 110, no. 3 July 20, 1922, pp. 143–145, 7 figs., *d*)

MOTOR-CAR ENGINEERING (See also Railroad Engineering)

10-Hp. Trojan Motor Car. This car, of British construction, has several unconventional features. The chassis may be described as a shallow box or tray, in and across which is mounted a two-stroke power unit and epicyclic gear, and at the corners of which are attached semi-elliptic cantilever springs supported at their free ends on tubular axles.

The engine has four cylinder bores arranged in a square in a single casting. It is, however, of the two-cylinder, two-stroke, three-port type, for each pair of cylinders has a common combustion chamber and a single spark plug. In each cylinder there is a three-ringed cast-iron piston with a long skirt and a plain head, the usual deflector employed in the majority of two-stroke engines being absent. The camshaft has two throws at 180 deg. The inlet pipe is taken to the center of the cylinder block and is led down between the cylinders where it branches into ports formed in each of the two lower cylinders. The opening of the ports is controlled by the difference of movement of the pistons due to the offsetting of the cylinders in relation to the crankshaft. As the pistons travel toward the top of the cylinders the mixture is drawn through the inlet port in the lower cylinder into the crankcase until the transfer port at the side of the upper cylinder is encountered, when it rushes through to the combustion space and is compressed there as the pistons ascend and draw in the next charge from the crankcase. As the pistons approach the top of this compression stroke, the mixture is fired by the spark plug in the upper cylinder. The upper piston is just behind the lower piston in its travel and there is a movement of the now burning mixture in the upper combustion chamber through the connecting port to the lower combustion chamber, so that turbulence of the gases is permitted right up to and during the period of combustion. As the pistons pass down the cylinders on the power stroke, the mixture in the crankcase is being compressed ready for transfer, and owing to the lead of the exhaust piston, the exhaust port in the lower cylinder is opened before the transfer port is uncovered. Thus the gas follows a circular path in its passage through the engine, for it enters at the base of the lower cylinder, passes through the crankcase, through the transfer port to the upper cylinder, thence to the lower cylinder, and out through the exhaust port.

The original article contains interesting details as to the lubrication and transmission system and it is stated that notwithstanding the use of solid tires, the riding in the car is comfortable. The body work is described as an "occasional" four-seater, for although four adults may be carried with ease, owing to the limitations imposed by wheelbase and the special design of the chassis as regards springing, the leg room is hardly sufficient for a long journey. (*The Autocar*, vol. 48, no. 1392, June 24, 1922, p. 1071–1072, 7 figs., *d*)

POWER-PLANT ENGINEERING (See also Steam Engineering)

Condenser-Tube Packing. Discussion of the subject, with particular reference to corrosion and crushing of tubes, and description of the John Crane flexible metallic-ring packing.

The author claims that corrosion is assisted by the insulation of the condenser tube from the iron shell by non-metallic packing, either at one or both ends, and that it may be reduced or eliminated

by bonding the tubes in good electrical contact with the tube sheets at both ends. It is said that the John Crane packing provides such a bond and in addition does not deform the tube at the point of packing contact.

In this particular device metal rings are used as packing material. These rings are built of many spiraled layers of very thin babbitt foil, so that while they are of metal they are also flexible and compressible. Each ring is die-formed so that it fits accurately the stuffing box for which it is intended.

In addition to this, special so-called expansion rings are used and each tube end requires two metal rings and two expansion rings, the expansion rings being apparently of fabric (asbestos). A special tool may be used for installing both types of rings. This tool may be of the hand-operated type for small condensers or of the pneumatic type for large condensers. (*The American Marine Engineer*, vol. 17, no. 6, June, 1922, pp. 25–31, 19 figs., *d*)

RAILROAD ENGINEERING

Gasoline-Driven Passenger Rail Cars

SOME RECENT DEVELOPMENTS IN GASOLINE-DRIVEN PASSENGER RAIL CARS, W. L. Bean. An extensive paper covering the subject of design of gasoline-driven passenger rail cars. The general field of utility of this type of rolling stock is for short-line railroads where traffic is not sufficiently dense to pay for operation by conventional steam trains.

Self-propelled railway cars have been in use for a considerable number of years, but it is only quite recently that they have found extensive application.

The author believes that the gasoline engine may be the main type in use, although light-weight Diesel-type machines may offer competition, and even steam is not out of the running on self-propelled rail cars. While the gasoline mechanical drive is at present in the forefront, there is a renewed interest and endeavor to revive the gas-electric system along new lines embodying lighter construction and less power than formerly used.

Many railroad men have been extremely doubtful about the success of a single pair of wheels operating on rails at speeds necessary for passenger service. It can be stated, however, that the greatest success has resulted and over a sufficient period of time to demonstrate there is nothing to be feared in the trailing of a single pair of wheels under a car of this sort. It is not recommended, of course, that cars be operated at high speed in reverse motion, but even so, it has not been noticed that any difficulty has been experienced in backing six-wheel rail cars; the usual backing movements being under speeds of 25 m.p.h.

In further consideration of the six-wheel arrangement, it may be stated authoritatively that there is no advantage in using more wheels under a car which can be propelled by any of the existing automotive-truck power plants. However, in order to secure acceptable riding qualities in the rear of a six-wheel vehicle, it is desirable to have a wheel of a relatively large diameter; namely, 36 to 40 in., and arrangements to absorb shocks by rubber and other devices in connection with springs. Special consideration should be given to keeping the unsprung weight to the absolute minimum.

Very casual investigation of the operation of six-wheel rail cars shows low operating costs per mile. Cars built on two- to three-ton chassis will travel eight to eleven miles per gallon of gasoline, and cars built on five-ton chassis from four to six miles. The consumption, of course, depends on atmospheric temperature, length of run, loading, grades and especially speed. Maintenance should not exceed five cents per mile on the smaller car or eight cents per mile on the larger ones, over a considerable period of time. Other operating and maintenance costs depend on local conditions, particularly as to wages. One man is required for the mechanical operation of the car, but whether he can handle the collection of tickets and the performance of such other duties, depends altogether on local conditions, and each railroad man can figure that out for himself. First cost of a car of the smaller type is usually around $9000, and of the larger one, around $16,000, depending on the refinements of construction of chassis and body, and particularly whether or not the body is built for severe or mild weather conditions.

The use of self-propelled cars may be novel to railroad men accustomed to think only of trains containing a multiplicity of units, and an earnest study of the engineering problems of single self-propelled car operation is important, as it will lead to better development of this class of rolling stock.

While, under some conditions, trailer operation may become desirable, the need at present is to develop a real single unit within the limits of weight carried by two 4-wheel trucks. The author discusses in detail some of the engineering features involved, one of which is the relation between engine speed and car speed, especially from the standpoint of vibration; and also the comparative features of gear-driven and gas-electric types.

The problem of heating self-propelled cars is discussed and some data given on wind resistance, chiefly taken from previously known sources.

In the discussion which followed, J. C. Cain, manager of purchases, American Short Line Railroad Association, has given some of the figures on the cost of maintenance and operation, as follows:

"We were furnished records of cars that had made as high as 300,000 miles, and which had been in practically continuous service for a period of five years. The operating cost varied from 10 to 25 cents per mile, and gasoline consumption from 5 to 10 miles per gal.

"We found maintenance cost surprisingly low, averaging about $15 per month on these smaller-type cars, and only slightly above this on the larger ones. By smaller type I mean those using a two and one-half or three-ton motor-truck chassis, and by larger cars those using five-ton chassis. The operating cost of 10 cents per car-mile was, of course, confined to the former, which were being operated by one man. But some of the larger types using two men were being operated at as low as 20 cents per car-mile, as follows:

Gasoline	$0.030 per mile
Labor, 2 men at $125 per month	0.085 " "
Depreciation, rate 12½ per cent	0.042 " "
Interest and insurance	0.022 " "
Maintenance	0.021 " "
Total	$0.200 per mile

"These figures were made on a basis of $12,500 purchase price of the car, and an operation of 106 miles per day." (*Official Proceedings of the New York Railroad Club*, vol. 32, no. 7, June 19, 1922, pp. 6713–6726, illustr., and discussion pp. 6726–6744, *g*)

DIESEL-ELECTRIC MOTOR CARS FOR RAILWAY SERVICE IN SWEDEN. The first Diesel-electric car in Sweden, built in 1913, had an engine of 75 hp., but lately cars have been built of 160 hp. and 250 hp., both types being now in regular service.

Cars of 160 hp. weigh 37,500 kg. (82,500 lb.) and, when grades do not exceed 1 per cent, are capable of hauling a trailing load of 67½ metric tons (74¼ short tons) at ordinary speeds. This is a total train weight of 105 metric tons (115½ short tons). Cars of 250 hp. weigh 50,000 kg. (110,000 lb.) and under the same conditions can haul a trailing load of 115 metric tons (126½ short tons), which corresponds to a train of 165 metric tons (181½ short tons), including the motor car. Plain trucks are used on the engine-compartment end of these cars, and motor trucks, one motor for each axle, under the other end. The cars can be operated equally well from either end. With the passenger cars used in Sweden, which are much lighter than are customary on American roads, the 160-hp. car can haul a train with about 225 passengers, while the 250-hp. car can haul a train holding 375 passengers.

When hauling full trains the fuel-oil consumption for the 160-hp. engine should average about 0.7 kg. per train-kilometer or 2.5 lb. per train-mile, while the consumption for the 250-hp. engine should average about 1.0 kg. per train-kilometer or 3.5 lb. per train-mile. Oil records of a 160-hp. motor car for an extended period in regular service handling a train of metric tons (99 short tons) showed a fuel-oil consumption of about 0.5 kg. per kilometer or 1.8 lb. per train-mile. By weight, the fuel-oil consumption of the Diesel engines averages about 6 per cent of that of the coal used by steam locomotives of the same power.

The 160-hp. engine has eight cylinders and the 250-hp. twelve cylinders, but otherwise they are similar in general design to the

smaller engines. A number of improvements have, however, been introduced in the later designs of motor cars. The cooling water for the Diesel engines in now recooled in a number of radiators similar to those used for gasoline motor trucks, mounted on the roof of the car as shown in one of the illustrations in the original article. Cooling is effected by means of a fan blower driven directly from the main engine and is thus independent of speed. The motors are now arranged to be connected either in series or in parallel.

In addition to low fuel costs, one-man operation, and little time or attention required at terminals, experience has shown that Diesel-electric motor cars can make a greater mileage per day, spend less time in the shop, and run for much longer periods without a general overhauling than steam locomotives. They are capable of making 50,000 to 60,000 miles per annum. Even after being taken in for overhauling after some 60,000 miles, it has been found that the largest item of expense is for dismantling and reassembling.

While the Diesel motor car or locomotive will undoubtedly be still further perfected and adapted to a wider railroad field of usefulness, indications point to a much more general employment of this type of motor in the near future. (*Railway Mechanical Engineer*, vol. 96, no. 6, June, 1922, pp. 314–315, 2 figs., *d*)

The Steam Unit Car, E. S. French. Brief data on a self-propelled steam-driven car. The car weighs in the vicinity of 60,000 lb. and uses oil as fuel. The boiler is of a water-tube sectional design.

The main engine is of the two-cylinder piston-valve type. At 800 lb. pressure the mean effective steam pressure at cylinders is around 450 lb. Temperatures of superheated steam run from 450 to 800 deg. fahr. The speed of the engine is quite low. At 25 m.p.h. the engine makes approximately 270 r.p.m. and at 60 miles, approximately 890 r.p.m. The horsepower developed at maximum speed would be about 1000 hp. (*Official Proceedings of the New York Railroad Club*, vol. 32, no. 7, May 19, 1922, pp. 6745–6746, *d*)

SPECIAL MACHINERY

An Automatic Hot-Billet Scraper, R. C. Rohrabacher. The method now generally employed for removing surface defects on billets before they pass to the finishing mill involves the use of air hammers and chisels, which is expensive and unhandy.

The new mechanism is to be set up between two of the stands of rolls in the series, and another precisely like it installed immediately following the last stand of rolls so that the billets leave the second scraper machine ready to be finished into whatever final product the plant makes.

The mechanism comprises sets of stellite scrapers designed to engage the surfaces of the passing billets at whatever pressure may be required to remove the flaws, means being provided also for automatically guiding the billets to the scrapers. Pressure is applied independently to each scraper blade, each machine having four cylinders, two of which operate horizontally and two vertically. The apparatus may be operated under air, steam, or water pressure.

Stellite is used for the scraper knives because of its high degree of red-hardness. (*The Iron Age*, vol. 109, no. 17, Apr., 1922, pp. 1126–1128, 5 figs., *d*)

Hydroelectric Bloom Shear. A new type of shear has been developed for cutting hot blooms as they come from the blooming mill in plants driven entirely by electricity. The new element which makes it possible to provide a powerful hydraulic shear with the advantages in speed possessed by a steam-hydraulic shear is a motor-driven hydraulic intensifier.

Hydraulic pressure for the lifting cylinders and the gag cylinder is supplied by a separate hydraulic accumulator directly connected to them by pipes and at a constant pressure of 1000 lb. per sq. in. Low-pressure water for the intensifier and the main hydraulic cylinder is supplied from a prefiller tank under an air pressure of about 60 lb. per sq. in. This makes the whole water system a closed one in which the only water wasted is that lost by leakage.

Power to the intensifier is supplied by a flywheel motor-generator set to a direct-current shunt-wound reversing motor of 700 hp. with a full-load speed of 86 r.p.m. This motor, through a pinion and rack, operates a hydraulic ram with a working stroke of 14 ft. running in a cast-steel intensifier cylinder. The intensifier unit has a length of about 63 ft. overall. (*The Iron Age*, vol. 109, no. 16, Apr. 20, 1922, pp. 1078–1079, 4 figs., *d*)

SPECIAL PROCESSES

Calorization, Prof. Leon Guillet. The author discusses in a general manner the various processes for protecting against external chemical action of surfaces of metallic objects, in particular the process known as calorization.

He became interested in this process in 1915 when he was searching for a method of protecting in case-hardening the parts of the surface where it was desirable to preserve the original properties of the material. There were several methods considered, such as a clay coating, immersion of the article in a bath of sulphate of copper, deposition of metal by the Schoop process, and electrolytic deposition. All of these methods, however, proved unsatisfactory in one way or another and then calorization was resorted to.

It is of interest to note that the author obtained apparently satisfactory results by calorizing not only iron and steel articles, but also articles made of copper and copper alloys. He found, however (the same as in this country), that the calorized surface is very hard and unsuitable for machining, so that all parts of calorized objects must be machined before calorization. Moreover, calorization is an expensive process, especially on pieces of any considerable dimensions, and is entirely unapplicable to very large pieces, which makes it desirable to evolve some method for producing the same result by simpler means.

In this connection it is stated that in 1919 in Germany attempts were made to calorize grate bars on four freight locomotives of the Prussian State Railways by the Schoop process, and that the very first tests showed that the resistance of the grate bars so treated was four times that of untreated bars. Similar experiments on grate bars of express locomotives have shown that while non-treated bars have to be replaced every six weeks, none of the treated bars showed any appreciable signs of wear after a service of four months. Similar experiments are being carried out on a large scale in Denmark. One of the interesting features discovered in the experiments made in Germany is that clinkers do not stick to the treated grate bars, which materially reduces the work of cleaning fires. Alumino-treatment by the Schoop process is said to be much simpler, cheaper and of more general application than calorization. At the same time it requires probably the observance of certain precautions, and the author states that he knows cases where the aluminum layer peeled off. (*Bulletin Technique du Bureau Veritas*, vol. 4, no. 4, April, 1922, pp. 83–86, 3 figs., *deh*)

Wire Manufacture in England and France, Kenneth B. Lewis. A brief description of the processes used in Europe as compared with American processes, of particular interest because it shows the reason for the difference in practice in the various countries.

In the opinion of the author the British make better wire than the Americans, largely because in America a good deal of the wire produced by the wire-drawing mills is consumed by some finishing department of the same concern and the raw material, in this case, wire, can be made cheaper if the finishing department can make a product less accurately sized. In England, the wire maker buys finished rod and sells the wire, as, for example, to the nail maker. The latter demands first-class wire in order to maintain a high output from the nail machines, and the wire maker has to deliver such wire and insists on getting high-grade rod.

Furthermore, the wire drawer and the nail maker are 100 per cent unionized. They are on a piece-work basis, and if they do not like the raw material they get, they walk out.

The labor union is the outstanding factor in the industry from every angle. In conditions under which the American wire drawer handles four, five and even six blocks, the British wire drawer is permitted by the union to run only two. He has an abundance of time on his hands, which makes it possible for the boss to insist on a high degree of accuracy in the finished product.

The wire drawer is required to fix his own dies. He points his wire frequently with a hammer and anvil. The arrangement is crude and wasteful of time, but the wire drawer has time to waste.

In some mills the wire drawer must walk into the baker, pick up the bundle of rod on the floor and carry it in his arms to the bench—at that the rod bundles are small. The practice is apparently wasteful of time, but the wire drawer's time is paid for anyway and does not cost the boss anything for these particular operations. The expenses for improved machinery for production and handling of large bundles would fall on the proprietor, while all the profits would go to the union wire drawer, which is the reason for maintaining the current practice.

The British wire drawer is a highly skilled artizan. He serves a long apprenticeship and works his whole life at the bench. He knows instinctively how to vary his drafting and the shape of the die hole to suit the variations in the stock, and he does make beautiful wire.

British wire-drawing companies are old concerns firmly established, mostly family affairs. Consolidations are not usual, some of the reasons being psychological and others due to the difficulty of buying land that would be necessary for a consolidation involving expansion. There is practically no land held for speculative purposes. Land may be leased, but, generally speaking, cannot be bought, and people are reluctant to invest in a big undertaking on leased land. Furthermore, the established units of business are chiefly in congested districts and if they are to be brought together, it must be in a new place. If this should be done, it is an open question as to whether the workmen will follow the plant. The British workman does not care to change from place to place, and the British manufacturer cannot count on attracting to a new location a sufficient number of floaters. There are no immigrants in England, no great floating body of unattached young men ready to be shaped into skillful or semi-skilled laborers. The manufacturers can look only to the ranks of union labor. He cannot make wire drawers or nail makers. The union makes them and the boss takes them. (*The Blast Furnace and Steel Plant*, vol. 10, no. 6, June, 1922, pp. 323–325, *gc*)

SPECIAL PROCESSES

THE MANUFACTURE OF SEAMLESS STEEL TUBES. Abstract from a recent issue of the *Ebbw Vale Works Magazine*, describing, among other things, the process used at these works.

Essentially this process does not differ from the standard methods, consisting of a piercing mill and a Pilger mill for rolling, the billet being then cold-drawn over a mandrel. (*The Iron and Coal Trades Review*, vol. 104, no. 2832, June 9, 1922, pp. 849, 1 fig., *d*)

STEAM ENGINEERING

High-Pressure Steam Generation

NEW DEVELOPMENT IN HIGH-PRESSURE STEAM GENERATION. Description of an experimental boiler designed for high pressure by the Power Specialty Co. and developed in coöperation with Thos. E. Murray, Inc.

The boiler is operated experimentally at 225 lb. pressure, but it is said that with slight modifications in structure it can be built for reliable operation at pressures up to 1000 lb. with the usual fluctuations in capacity required to be carried by modern single-service stations.

In this boiler the economizer delivers water to the boiler at approximately steam temperature, the boiler adding the heat of evaporation, and the steam is then led downward to the superheater on the rear furnace wall.

Each unit tube consists of two straight tubes rolled into a connecting member so as to form a hairpin shape from header to header, and the heating surface of the tubes is increased by means of "gilled rings" shrunk on the tubes. Each gilled-ring section contains five rings and by means of these rings the heating surface and the total heat transfer is increased to about six times that of the bare tube, in addition to which the shrunk sections increase the tube strength. A sealed spacing tube is contained internally and forces the water and steam into a thin annular path between it and the 2-in. tube.

Each section of the boiler receives water from a common horizontal drum and delivers steam through a vertical header into a horizontal drum. Water enters the lower end of each hairpin-shaped tube by means of a vertical water header. An equalizing pipe connects the vertical steam headers together. Since a small circular drum is much stronger for the same thickness of metal than one of larger diameter, the advantage of a large drum is obtained from a combination of small seamless structures, which are better suited for high pressure.

The relatively small boiler element absorbs heat at temperatures varying from approximately 2700 deg. fahr. to 700 deg. fahr. This produces a higher rate of heat transfer than in types with usual

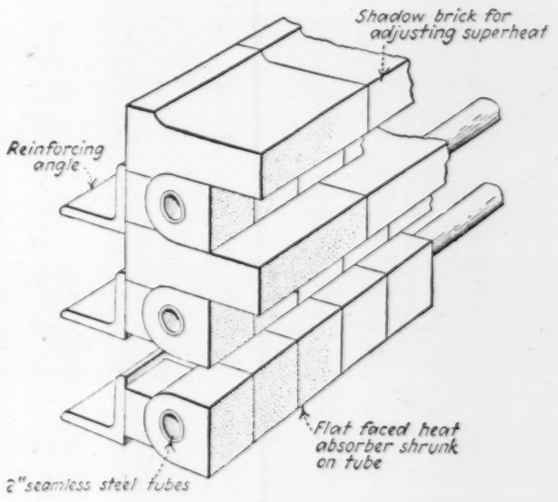
Shadow brick for adjusting superheat
Reinforcing angle
Flat faced heat absorber shrunk on tube
2" seamless steel tubes

FIG. 7 RADIANT-HEAT SUPERHEATER DETAILS

lower temperature of escaping gases, so that 90 per cent of the work ordinarily done by the boiler element is here accomplished with approximately 60 per cent of the usual heating surface.

The economizer is composed of tubes similar to those of the boiler and has to be usually large as it is designed for entering gases of 700 deg. fahr. in order to produce feedwater close to steam temperature.

Water from the service pump at 100 lb. per sq. in., 80 deg. fahr. was employed in cleaning the heating surface once every twenty-four hours. This operation required ten to fifteen minutes and did not interfere with regular performance of duty, except in lowering the boiler-feed temperature for a period of less than one-half hour.

The Foster radiant-heat-element superheater is used, its advantage in this case lying in the fact that it is not affected by the weight of gas produced and therefore gives fairly steady superheat over a large range of capacity.

Fig. 7 shows a detail of shadow brick, tubes and flat-faced heat absorbers which are shrunk on the tubes. These produce 80 sq. ft. of heating surface. Reinforcing angles are bolted to these absorbers at intervals of 18 in. The amount of superheat may be adjusted by changing these shadow brick. The main blow-off valve is placed at the bottom of the superheater, while an auxiliary valve, adjusted for a higher blow-off pressure, is placed on the main boiler header. Piping is led from the economizer, making it possible to flood the superheater while the fire is being raised, or whenever required otherwise.

The original article gives results of two steaming tests. It is stated that the unit has been in service over an extended period, been tested under a large range in capacity, and is now in successful daily use with the other plant boilers at the Municipal Gas Company Plant, Albany, N. Y. (*Power*, vol. 56, no. 4, July 25, 1922, pp. 131–133, 4 figs., *dA*)

CLASSIFICATION OF ARTICLES

Articles appearing in the Survey are classified as *c* comparative; *d* descriptive; *e* experimental; *g* general; *h* historical; *m* mathematical; *p* practical; *s* statistical; *t* theoretical. Articles of especial merit are rated *A* by the reviewer. Opinions expressed are those of the reviewer, not of the Society.

ENGINEERING RESEARCH

A Department Conducted by the Research Committee of the A.S.M.E.

Research Résumé of the Month

A—Research Results

The purpose of this section of Engineering Research is to give the origin of research information which has been completed, to give a résumé of research results with formulas or curves where such may be readily given, and to report results of non-extensive researches which in the opinion of the investigators do not warrant a paper.

Aeronautics A1-22. Radiators for Aircraft Engines. Technologic Paper No. 211 of the Bureau of Standards, available for sale by the Superintendent of Documents, Government Printing Office, Washington, D. C., at fifty cents per copy, describes the laboratory investigations relating to aircraft-engine radiators which were conducted by the Bureau during the World War and in the two years immediately succeeding it. Individual reports covering many phases of the subject have been published previously by the National Advisory Committee for Aeronautics and in scientific and engineering journals. These reports, however, lack the systematic coördination, uniform terminology, and unified mathematical treatment which should characterize a handbook on the subject. Moreover, the problems which were investigated first because of their greater importance and which were the subjects of the earliest reports are for that reason not so well covered as is now possible because the later work has thrown much additional light upon matters not settled at the time of the publication of the earlier reports. Accordingly, the present paper is a revision and recompilation of the material available.

Refrigeration A1-22. Ammonia Tables. The Bureau of Standards has completed the measurements for a table of the thermodynamic properties of ammonia. The entire series of separate but correlated researches relating to the behavior of ammonia as a refrigerating agent has extended over a period of 8 years.

The results of the entire series of measurements are embodied graphically in a Mollier chart which was presented May 25 at the Detroit meeting of the American Society of Refrigerating Engineers. This chart is doubtless the only similar chart of thermodynamic properties of a working fluid for a heat engine which is based entirely upon actual measurements made in one laboratory, upon a fluid of a definite quality, in a program of separate investigations, each complete, each planned and executed according to a high standard of accuracy, and all extending over the entire range of conditions to be covered by the table. The resulting data have been made thermodynamically consistent, not by mutual adjustment of values or by arbitrary choice, as in the previous tables, but by perfection of experimental technique to the point where outstanding discrepancies are negligible. In this respect, the chart is unique in its class. It is now published merely as a preliminary edition, subject to revision.

Air A1-22. Compressed-Air Illness and Its Engineering Importance. Dr. Edward Levy, Consulting Physiologist, Bureau of Mines is the author of Technical Paper No. 285 on the above subject.

The effect of compressed air upon the life, health, and efficiency of workers in deep mining or subaqueous tunneling becomes of increasing importance in the study of occupational diseases and the medical problems of industries.

This report relates the experience of the author in curative and preventative work as physician to the Public Service Commission for the First District, State of New York, which supervised the building of the four pairs of tunnels constructed under the East River during the years 1914 to 1919.

Address the Superintendent of Documents, Government Printing Office, Washington, D. C. Price ten cents.

Electrochemistry A1-22. Generated Voltage of Cells at Low Temperatures. Scientific Paper No. 434 of the Bureau of Standards, for sale by the Superintendent of Documents, Government Printing Office, Washington, D. C., at five cents per copy, deals with the generated voltage of dry and storage batteries at low temperatures. The practical importance of a knowledge of the behavior of these two types of batteries at low temperatures has arisen from their use in the arctics and at high altitudes. Measurements were made on dry cells and storage batteries cooled to —72 deg. cent. (—98 deg. fahr.) by carbon dioxide snow and to —170 deg. cent. (—274 deg. fahr.) by liquid air. The Gibbs-Helmholtz equation was applied to the observations, and excellent agreement between theory and observation was found. At the lowest temperatures, high values of voltage were sometimes observed, and the polarity was often reversed. A possible explanation based on the Nernst equation is given.

Glue and Gelatin A2-22. The Chemistry and Technology of Gelatin and Glue. Dr. R. H. Bogue, who has been engaged since 1915 in research on gelatin and glue at the Mellon Institute, Pittsburgh, Pa., has completed a comprehensive treatise on The Chemistry and Technology of Gelatin and Glue. This work is being published by the McGraw-Hill Book Company, Inc. Dr. Bogue's consideration of the standardization of testing methods will be of interest to mechanical engineers. A brief account of Dr. Bogue's work appeared in the July, 1922 issue of the *Journal of The Franklin Institute*, pages 75-82.

Health and Sanitation A1-22. Compressed-Air Illness and Its Engineering Importance. *See* Air A1-22.

Industrial Management A1-22. Industrial Fatigue Research. A list of the topics discussed in the Annual Reports of the Industrial Fatigue Research Board (London) contains the following:

Hours of Work and of Ventilation, Influence of, on Output in Tinplace Manufacture (1919). With Illustrations and Statistical Tables. Price 0s, 6d.

A Study of Improved Methods in an Iron Foundry. (1919) Price 0s, 2d.

Fatigue and Efficiency in the Iron and Steel Industry. (1920) With Pla es and Charts. Price 3s, 0d.

Adaption of Output to Altered Hours of Work, Speed of. (1920) With Plate and Charts. Price 1s, 0d.

Individual Differences in Output in the Cotton Industry. (1920) Textile No. 1. Price 0s, 6d.

A Statistical Study of Labour Turnover in Munition and other Factories. (1921) Price 3s, 0d.

Motion Study in Metal Polishing. (1921) (Metal No. 5). Price 2s, 0d.

Time and Motion Study. (Illustrated) (1922) Price 2s, 0d.

Address H. M. Stationery Office, Imperial House, Kingsway, W. C. 2, London.

Iron and Steel A3-22. The Nick-Bend Test for Wrought Iron. The "nick-bend" test is included in nearly all specifications for wrought iron. The usual statement says that the fracture of the nicked bar shall show no crystalline areas, or at least not more than a specified per cent. The clause, as usually given in American specifications, allows the nicked bar to be broken either by pressure or by blows. Foreign specifications of this test differ widely from American practice and from each other.

An investigation by the Bureau of Standards consisted in the fracturing, under known conditions, of nicked bars of 9 grades of wrought iron furnished by 5 different manufacturers. The composition, structure, and mechanical properties of the materials were determined, and the method of fracturing varied from simple transverse bending to severe impact, these extremes being permitted by current specifications.

A paper on this subject was presented at the June meeting of the American Society for Testing Materials, by Messrs. H. S. Rawdon and S. Epstein of the Bureau of Standards.

Light A1-22. Interference Methods for Standardizing and Testing Precision Gage Blocks. Scientific Paper No. 436 of the Bureau of Standards describes interference methods by which the planeness and parallelism errors of precision surfaces can be measured, and the length of standard gages can be determined by direct comparison with the standard light waves with an uncertainty of not more than a few millionths of an inch. The errors of other gages can be determined by comparison with these calibrated standards with equal precision. The process makes the standard light waves, determined to 1 part in 4 or 5 million, the standards of length for this work. The apparatus used for calibrating standards and comparing other gages with these standards is illustrated by line drawings and thoroughly explained. The paper may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at ten cents per copy.

Paints, Varnishes and Resins A4-22. Carbon Black—Its Manufacture, Properties and Uses. This is the title of new Bureau of Mines Bulletin No. 192 by R. O. Neal and G. St. J. Perrott.

The authors point out in this paper that the present process of making carbon black recovers only a small percentage of the carbon in the gas, yet no other process in practical operation produces a material with properties similar to carbon black. Inability to secure carbon black would deal a serious blow to the printing industry, and inconvenience rubber manufacturers. On account of the diminishing supply of natural gas, development work should be conducted on more efficient methods of manufacture and production from other materials.

Carbon black is coming into extensive use in paints, since it has a higher tinting strength than any other black, consequently a given weight will obscure a greater area of surface.

Address the Superintendent of Documents, Government Printing Office, Washington, D. C. Price per copy twenty-five cents.

Petroleum and Allied Substances A8-22. Methods for Testing Petroleum Products. For a number of years a Federal Technical Committee made up of representatives of nine of the Government departments or bureaus

has been working on a set of specifications for petroleum products. This committee's work has been reviewed by the present Interdepartmental Committee on Standardization of Petroleum Specifications and its Advisory Board of seven representatives of the same number of civilian organizations, and has been finally adopted by the Federal Specifications Board. It is known as Bureau of Mines Technical Paper 305. This report covers specifications for gasoline, naphthas, burning oils, fuel oils, and lubricants. Address Superintendent of Documents, Government Printing Office, Washington, D. C. Price five cents.

Railroad Rolling Stock and Accessories A3-22. THE PROPERTIES OF CHILLED-IRON CAR WHEELS. The scope of this investigation was revised and extended until it included tests to determine (1) the strains caused by mounting the wheel on its axle; (2) the strains caused by the static or wheel loads; (3) the ultimate breaking strength of flanges and strains caused by flange pressure; (4) the strains, due to temperature gradients in the wheel, caused by brake application; (5) incidental problems related to the above. Professors J. M. Snodgrass and F. H. Guldner, of the University of Illinois, conducted the experiments, on which this Bulletin No. 129 is based. In this work the University of Illinois Engineering Experiment Station had the coöperation of the Association of Manufacturers of Chilled Car Wheels.

The present bulletin gives the results of a series of strain-gage tests in connection with the items (1) and (2) just mentioned; that is, tests made to determine the strains produced within the wheel by mounting it on its axle, and by the application of wheel loads. The strain within the wheel caused by forcing it on an axle was first determined for two 33-in. 725-lb. M. C. B. wheels. The same pair of mounted wheels was then subjected to static loads ranging from 20,000 to 200,000 lb. per wheel, and the resulting strains noted. The loading effect was produced by applying the load to the axle by means of a testing machine, and allowing the wheels to transmit it to a pair of rails, the conditions being similar to those found in service. A similar set of tests was carried out with a pair of 33-in. 740-lb. arch-plate-type of wheels. Additional tests for the purpose of obtaining more complete information concerning the mounting strains were then made upon a pair of 33-in. 725-lb. M. C. B. wheels. The reporting of the results of the mounting and static tests upon the wheels just mentioned is the purpose of the present bulletin. It is intended to publish additional reports dealing with tests to determine the ultimate strength of flanges, the effect of flange pressure, and the effect of brake applications, together with the related problems of brake friction and the thermal expansion of cast iron. The report is fully illustrated and the data are shown in the form of curves and charts.

B—RESEARCH IN PROGRESS

The purpose of this section of Engineering Research is to bring together those who are working on the same problem for coöperation or conference, to prevent unnecessary duplication of work and to inform the profession of the investigators who are engaged upon research problems. The addresses of these investigators are given for the purpose of correspondence.

Automotive Vehicles and Equipment B3-22. POWER LOSSES IN AUTOMOBILE TIRES. The Bureau of Standards has undertaken a general investigation of automobile tires and inner tubes. In connection with this work a rather comprehensive program has been laid out for dynamometer tests, to study among other things the power losses or energy dissipated into heat in tires operated under different conditions of axle load, inflation pressure, speed, temperature, and tractive effort. Preliminary tests have been made to determine the influence of these factors, which, aside from matters of design, are the principal items affecting the power loss in a tire. A continuation of the work will involve problems of design and construction, the influence of "oversize" tires and of "cord tires" on power losses, mileage, and general efficiency of operation. An investigation will be made of inflation pressures as affecting the efficiency and economy of tire operation. Tests will be made to determine the effects of tire fillers, shields, puncture-proof tubes, etc., and the properties of cushion tires will be studied.

For copy of preliminary report known as Technologic Paper of the Bureau of Standards No. 213 by W. L. Holt and P. L. Wormeley. Address the Superintendent of Documents, Government Printing Office, Washington, D. C. Price five cents.

Corrosion B4-22. CORROSION OF METALS BY ACID MINE WATERS. In the course of the general investigation of metal corrosion by mine water, being conducted by the Bureau of Mines at Pittsburgh, Pa., a study has been undertaken of the microscopy of corroded metals and alloys for the purpose of examining the preferential and differential corrosion of constituents in alloys under the action of different corroding media. The work will be done under the direction of R. J. Anderson, metallurgist, with the assistance of George M. Enos, research fellow. Address H. Foster Bain, Director, Bureau of Mines, Washington, D. C.

Ferrous Alloys. MAGNETIC PROPERTIES OF PURE ALLOYS OF IRON AND CARBON. See *Magnetism B2-22.*

Foundry Equipment, Materials and Methods B4-22. MOLDING SAND. In coöperation with the joint committee of the National Research Council and the American Foundrymens' Association, the Bureau of Standards is investigating standard methods of testing molding sands. The formulation of the fineness test is practically complete, and the cohesiveness and other physical tests are well under way.

Fuels, Gas, Tar and Coke B2-22. BLAST-FURNACE COKE, ITS PHYSICAL PROPERTIES. Investigations now being conducted by the Bureau of Mines at the Southern experiment station, Birmingham-Tuscaloosa, Ala., cover the physical properties of blast-furnace coke, including physical tests, solubility of coke in carbon dioxide, and analyses of blast-furnace hearth gas. In the study of the reactivity of coke with carbon dioxide, the effect of mesh of coke, temperature, rate of flow of carbon dioxide, and dilution with nitrogen has been further investigated. Six furnaces have been investigated in the Southern district. Experimental work is being conducted also at the Pittsburgh, Pa., experiment station of the Bureau of Mines on the influence of fineness, medium, and time of boiling, in determining the true specific gravity of coke, which determination is used in calculating the amount of cell space or porosity of metallurgical coke.

Iron and Steel B2-22. EFFECT OF RATE OF HEATING IN HARDENING STEELS. The rate of heating for hardening has rarely been accurately regulated though it is apparently of considerable importance, at least in some steels and under certain conditions where control in dimensional changes in quenching is desired. This question is, therefore, of vital importance to manufacturers of die castings and in the production of thread gages. A series of 16 samples of chrome-vanadium die steel was hardened, using various rates of heating, and these dimensional changes noted. Unfortunately, the desired uniformity of results was not always obtained, but in view of the discrepancies found in other types of tests on the same steel, it is believed that the metal did not have the required uniformity. Similar tests of different steels will be carried out during the month and upon their completion further comments concerning these changes will be made. Address S. W. Stratton, Director, Bureau of Standards, Washington, D. C.

Iron and Steel B3-22. RESISTANCE OF CHROMIUM STEELS TO ACID CORROSION. See *Corrosion B4-22.*

Magnetism B2-22. MAGNETIC PROPERTIES OF PURE ALLOYS OF IRON AND CARBON. Experimental work has been completed by the Bureau of Standards on an investigation of the magnetic properties of a series of very pure alloys of iron and carbon. A number of alloys were prepared having carbon contents ranging from 0.018 to 1.60 per cent and containing no impurities in sufficient amounts to be of importance. Normal induction and hysteresis data were obtained for magnetizing forces up to 2500 gilberts per cm. and the results correlated not only with the carbon content but also with heat treatment. The reluctivity relationship previously used in the study of a carbon steel of eutectoid composition was found to be useful in correlating the results. A paper describing the results of this investigation is now in the course of preparation.

Metal Manufactures, Miscellaneous B1-22. ENAMELING OF METAL PLATES. During the past month the Enameled Metals Section of the Bureau of Standards has made an investigation of kitchen-ware enamels. About ten ground coats have been applied to 8-in. steel plates and coated with each of seven cover enamels, representatives of a series of enamels with varying composition. Some 600 plates have been enameled during the month. They are now being tested for resistance to impact, to thermal shock, and to acids, but the work has not yet progressed to a point where conclusions can be drawn. Some very interesting information, however, has been developed regarding the effect of variations in composition on the burning range, burning properties, and fish scaling.

Non-Ferrous Metals B2-22. MAGNETIC DETERMINATION OF IRON AS AN IMPURITY IN BRASS. The presence of iron in brass is sometimes objectionable as it exerts a bad influence on the mechanical properties or interferes with cutting. For this reason, a rapid non-destructive method for its determination would be of value. In order to investigate the possibilities of a magnetic test in this connection, the Bureau of Standards has made a study of the magnetic properties of a series of samples of cast brass containing varying amounts of iron up to one per cent. It was found that the physical condition of the material as affected by heat treatment exerted a great influence on its magnetic properties, and that a quantitative determination, at least for the type of material investigated, is not feasible. There is no direct relationship between the magnetic properties and the carbon content.

Petroleum and Allied Substances B1-22. TEMPERATURE-PRESSURE CURVES OF PETROLEUM PRODUCTS. In the course of investigations now in progress by M. B. Cooke, assistant refinery engineer, of the Bureau of Mines, into the nature of "gum-forming" constituents of gasoline, several gasolines and other petroleum products were heated in a small bomb, and pressures of considerable magnitude were developed. As the Bureau has received many inquiries for data showing the pressure that may be developed in a still when gasoline or other oil is subjected to elevated temperatures, it was thought advisable to record the pressures observed at various temperatures in the course of this work. These data were merely a by-product of the main investigation.

Gasoline and similar products are very complex mixtures, and it is difficult to determine accurately the true vapor pressures, hence the vapor pressures of the oils used in these tests have not been studied in detail, but the data obtained may be taken as representative of the pressure-temperature relations of the various oils in commercial work. Address H. Foster Bain, Director, Bureau of Mines, Washington, D. C.

Petroleum and Allied Substances B2-22. Oil Shale Investigations. At Boulder, Colo., at Salt Lake City and at Indiana University the Bureau of Mines in coöperation with the state institutions is carrying on intensive investigations into the best methods of distilling and refining the shale oil found in these localities.

Steel, Its Treatment and Products B5-22. Wear of Steels. Experiments have been started in the study of the rate of, or resistance to wear of, steels run in contact without lubrication. The Amsler wear-testing machine is being used for this investigation. The steels included in the preliminary studies form a series that has been submitted by the Gage Steel Committee and which is being studied in detail to determine the suitability of the steels for gages. In gage work, the question of wear is of extreme importance. Address S. W. Stratton, Director, Bureau of Standards, Washington, D. C.

Steel, Its Treatment and Products B6-22 The Mechanical Working of Invar. Invar steel, an important alloy where very low coefficient of expansion is desired, is very difficult to work mechanically. In order to see whether it could not be worked successfully, four small ingots of invar were prepared by the Metallurgical Division of the Bureau of Standards. The first attempt at forging was unsuccessful, the ingot cracking and breaking under the forging press. The second attempt was quite satisfactory as a result of very careful handling during forging operations.

It was found necessary to give very light reductions and not allow the forging temperature to drop below 1000 deg. cent. during the first reduction. This ingot was forged to a $^3/_8$-in. rod, and a portion of this was cut off and machined to a $^1/_4$-in. rod. This has been cold drawn with two intermediate annealings down to approximately $^1/_{16}$-in. wire. It is being carried further with the idea of determining how fine a wire of invar may be made.

Steel, Its Treatment and Products B7-22. The Effect of Manganese on the Magnetic Properties of Steel. It has been recognized for some time that manganese has an effect on the magnetic properties of steel which is of a somewhat similar nature to that of carbon. A series of iron-carbon-manganese alloys of exceptional purity have become available for a study of their magnetic properties. Several sets of specimens, each set having the same carbon content, but varying manganese, will be subjected to standard heat treatment and their magnetic properties determined. New apparatus for the testing of small specimens recently developed at the Bureau of Standards is being used in this investigation.

Steel, Its Treatment and Its Products B8-22. Effect of Rate of Heating in Hardening Steels. *See Iron and Steel B2-22.*

Ventilation B2-22. Relative Comfort Measurements by Means of Katathermometer. The katathermometer is an instrument contrived by Dr. Leonard Hill, an eminent English physiologist, and its various features have been fully described by him in his book entitled The Science of Ventilation and Open-Air Treatment. He made exhaustive experiments and concluded that the rate of cooling of the human body was the controlling factor in determining comfort or discomfort, and then set out to make an instrument that would measure this rate of cooling. The resulting instrument, the katathermometer, measures its own rate of cooling when its temperature approximates that of the human body and thus serves as an index of the rate of cooling of the body itself.

In connection with the coöperative metal-mine dust and ventilation investigations of the U. S. Bureau of Mines and the U. S. Public Health Service, some underground data have been obtained with intent to ascertain the adaptability of the katathermometer for determining the comfort of working places in mines. This preliminary study indicates that the instrument will probably be useful for making routine determinations of comfort conditions in our mines, and that it may also prove an important accessory for investigative work on problems in ventilation and kindred subjects in both coal and metal mines, although the instrument should probably be altered somewhat for maximum utility under the varied conditions in the mines of the United States.

By means of this instrument an exact numerical index of the relative comfort of a working place may be obtained, free from any personal equation, as determined by the temperature, pressure, relative humidity and motion of the air of the place. The instrument cannot take into consideration such vital elements affecting comfort as chemical impurity of air and presence of various kinds and quantities of dust, both of which may become determining factors in comfort of underground workers; nor measure the effect of undue noise, cramped positions, etc., which also may be important items in determining comfort of underground workers.

The authors of this Bureau of Mines Report of Investigation Serial No. 2355 are D. Harrington and G. E. McElroy. For further information address H. Foster Bain, Director, Bureau of Mines, Washington, D. C.

D—Research Equipment

The purpose of this section of Engineering Research is to give in concise form notes regarding the equipment of laboratories for mutual information and for the purpose of informing the profession of the equipment in various laboratories.

Chemistry, Industrial D1-22. The Mellon Institute of Industrial Research. The 9th Annual Report of Director Edward R. Weidlein has just been issued and serves as a reminder of the service which this institution is prepared to render industry through its system of Industrial Fellowships.

F—Bibliographies

The purpose of this section of Engineering Research is to inform the profession of bibliographies which have been prepared. In general this work is done at the expense of the Society. Extensive bibliographies require the approval of the Research Committee. All bibliographies are loaned for a period of one month only. Additional copies are available, however, for periods of two weeks to members of the A.S.M.E. These bibliographies are on file at the headquarters of the Society.

Aeronautics F1-22. Air Navigation, Theoretical and Practical. This bibliography in addition to giving a selected list of articles on aerial navigation contains selective references to allied subjects, such as Astronomy, Meteorology, Nautical Pilotage and Navigation, Cartography and Terrestrial Magnetism. Address Intelligence Branch, The Air Board, Ottawa, Canada.

Fluid Flow F1-22. Turbulent Flow of Fluids. This bibliography contains all the recent articles of importance on subject named in its title. It consists of two typewritten pages and is known as Search No. S. 3572.

Lubricants F1-22. Emulsification of Lubricating Oils. A bibliography of two typewritten pages. Search No. S. 3574.

Machine Parts F1-22. Gears. This is a fairly comprehensive bibliography of recent magazine and textbook articles on the subject of gears. It consists of five typewritten pages and is known as Search No. S. 3562.

Paints, Varnishes and Resins F1-22. Carbon Black—Its Manufacture, Properties and Uses This ten-page bibliography forms an appendix to Bulletin No. 192 on this subject recently issued by the Bureau of Mines. Address Director H. Foster Bain, Bureau of Mines, Washington, D. C.

Photography F1-22. Air Photographic Surveying and Mapping. The Intelligence Branch of The Air Board, Ottawa, Canada, has just completed three bibliographies on the general subject of aerial photography. One of them is named above and a copy may be secured by addressing the Air Board direct.

Photography F2-22. Forestry Reconnaissance and Forest-Fire Protection by Air. Address Intelligence Branch, The Air Board, Ottawa, Canada.

Photography F3-22. Air Photography, Generally. Address Intelligence Branch, The Air Board, Ottawa, Canada.

WORK OF THE A.S.M.E. BOILER CODE COMMITTEE

THE Boiler Code Committee meets monthly for the purpose of considering communications relative to the Boiler Code. Any one desiring information as to the application of the Code is requested to communicate with the Secretary of the Committee, Mr. C. W. Obert, 29 West 39th St., New York, N. Y.

The procedure of the Committee in handling the cases is as follows: All inquiries must be in written form before they are accepted for consideration. Copies are sent by the Secretary of the Committee to all of the members of the Committee. The interpretation, in the form of a reply, is then prepared by the Committee and passed upon at a regular meeting of the Committee. This interpretation is later submitted to the Council of the Society for approval, after which it is issued to the inquirer and simultaneously published in Mechanical Engineering.

Below are given the interpretations of the Committee in Cases Nos. 365 and 396 to 405 inclusive, as formulated at the meeting of June 29, 1922, and approved by the Council. In accordance with the Committee's practice, the names of inquirers have been omitted.

Case No. 365

Inquiry: Is it permissible, under the requirements of the Boiler Code, to weld together the outwardly projecting edges of furnace door hole flanges by the autogenous process, provided the form of the circular door opening and the autogenous or fusion welding

is as shown in Fig. 19 and the staybolting around the opening does not exceed the permissible staybolt pitch as given in Par. 199?

Reply: It is the opinion of the Committee that a circular door opening, of the form shown, in which the projecting cylindrical portion of the inside sheet is provided with an outwardly turned flange, at its extreme edge, to form an abutment for the edge of the circular projecting flange of the outside sheet, and is made leak-proof by autogenously filling the space between these two flanges, will meet the requirements of the Boiler Code, provided the circumference of the outwardly turned flange on the cylindrical projection of the inside sheet exceeds the outer circumference of the flange of

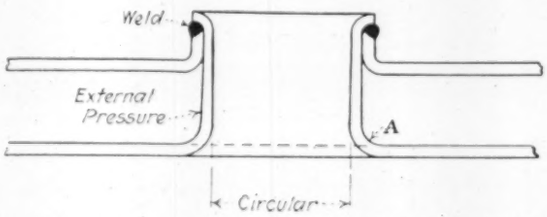

FIG. 19 CONSTRUCTION OF FURNACE DOOR OPENING WITH OUTWARDLY PROJECTING EDGES FLANGED AND AUTOGENOUSLY WELDED

the outside sheet, and provided that the thickness of this cylindrical projection of the inside sheet conforms to the requirements of the following formula:

$$P = \frac{5000 \times t}{R}$$

where

P = maximum allowable working pressure in lb. per sq. in.
t = minimum thickness of the plate forming the circular door opening in in.
R = the radius of the outer surface of the circular door opening in in.

CASE NO. 396

Inquiry: Is it permissible, under the requirements of Par. 257, to calk the heads of rivets? If so, how shall it be done and with what type of tools? Is it permissible to cut the plate or butt strap underneath the head and force the projecting metal up under the head?

Reply: It is the opinion of the Committee that it is permissible to calk the head of a rivet, if the rivet is not loose, provided the number of rivets requiring calking is not objected to by the inspector as indicating improper workmanship. Such calking must be done with a round-nosed or other type of tool which will not score or damage the plate under the head. The plate under the head should not be cut in order to force the metal up and make the head tight.

CASE NO. 397

Inquiry: Was it the intent, in Par. 199, to permit a value of 175 for C where copper washers were used as described in the definition for C?

Reply: It is the opinion of the Committee that the washers should be of steel to permit the use of 175 for C. Copper washers may be used provided no increase is assumed in the value of C for the strength of the washer.

CASE NO. 398

Inquiry: Is it permissible, under the requirements of the Boiler Code, to use a single-piece dome, with the shell drawn or pressed out of one piece, eliminating the lap seam and riveting of dome head to dome shell?

Reply: It is the opinion of the Committee that it was not the intent of the Code to prohibit the use of seamless construction otherwise built in accordance with the Rules.

CASE NO. 399

Inquiry: Is it permissible, under Par. 199 of the Code, to use a value of 175 for the constant C in the formula when the outside washer is omitted and instead an inside doubler plate securely riveted to the plate is used?

Reply: It is the opinion of the Committee that if three-fourths of the combined thickness of the boiler plate and doubler plate is used for the value of T in the formula, the value of 175 for C cannot be used unless outside washers are employed. It is the opinion of the Committee that if the thickness of the boiler plate is used for the value of T in the formula without adding anything for the thickness of the doubler plate, the doubler plate may be considered as the equivalent of the outside washer and the value of 175 may be used for C.

CASE NO. 400

Inquiry: Is it the intent of the Code that Par. 183, specifying the distance from centers of rivet holes to edges of plates, shall apply only to longitudinal joints, or is it applicable also to girth joints, manhole frames and other riveted attachments?

Reply: Par. 183 refers only to longitudinal joints.

CASE NO. 401

Inquiry: In Par. L-31, is it the intent that the area to be stayed is calculated from the maximum pitch squared, or the product of the actual pitches of the area supported by the stay under consideration?

Reply: The formula cited is based on the use of flat and not curved plates. In the absence of authentic data as to the reduction in stress that may be obtained due to curving the sheets, stayed curved sheets were made subject to the rules for staying flat plates. In the revision of the Code which is now under way, such allowances will be made for stayed curved plates in conformity with rules which have been developed since the last printing of the Code. For calculating the stress in staybolts the area of surface supported can of course be used. However, for spacing of stays or estimating stresses in stayed sheets, it will not be admissible to substitute the area of surface supported for p^2.

CASE NO. 402

Inquiry: Is it necessary, under Par. 195, where more than one manhole opening is inserted in a dished head, to increase the thickness of the head by more than $^1/_8$ in.?

Reply: It is opinion of the Committee that it is not necessary to increase the thickness of the head more than $^1/_8$ in. if more than one manhole opening is inserted, provided the minimum distance between the manhole openings is not less than one-fourth of the outside diameter of the head.

CASE NO. 403

Inquiry: Where a steam drum or dome is attached to a boiler, is this drum or dome to be considered a part of the boiler in applying the requirements of Pars. 277 and 278 for the attachment of safety valves?

Reply: It is the opinion of the Committee that where a steam drum or steam dome is attached to a boiler, the safety valve or valves, under ordinary conditions, may be located on this drum or dome. The area of the connection between the boiler shell and the drum or dome shall conform to the requirements in Par. 290.

CASE NO. 404

Inquiry: If a dished head is formed with a flattened spot or surface for the attachment of a connection or flange, is there any limit to the size of the plane or flattened spot on the head?

Reply: It is the opinion of the Committee that the diameter of the flat spot formed in the head should not exceed the value of p as given in the formula in Par. 199 or in Table 4, for the pressure and thickness of head involved.

CASE NO. 405

Inquiry: If a boiler constructed to the requirements of the A.S.M.E. Code for Boilers of Locomotives, is removed from the locomotive and operated for stationary or portable service, will the rules under which the boiler was constructed still apply?

Reply: The rules for the Construction of Boilers of Locomotives do not apply to portable locomotive-type boilers, such as are used for steam shovels, steam cranes, road rollers, and portable boilers used for threshing grain or cutting lumber.

If a locomotive boiler is removed from the locomotive and used in stationary or portable service, it shall be treated in accordance with Parts I or II of the Code for Stationary Boilers.

CORRESPONDENCE

CONTRIBUTIONS to the Correspondence Department of MECHANICAL ENGINEERING are solicited. Contributions particularly welcomed are discussions of papers published in this journal, brief articles of current interest to mechanical engineers, or comments from members of The American Society of Mechanical Engineers on activities and policies of the Society in Research and Standardization.

The Accuracy of Boiler Tests

TO THE EDITOR:

In the Accuracy of Boiler Tests, published in the July issue of MECHANICAL ENGINEERING, Mr. Cotton's estimate of a plus or minus 3 per cent error in a "regular carefully conducted boiler test" is more or less justifiable according to what is meant by a carefully conducted test and particularly according to the length of such test. No doubt there are many boiler trials made, the accuracy of which is not closer than plus or minus 5 per cent. In fact a boiler test made with coal fuel never is and never can be accurate. Besides all the other reasons for this the difficulties of samplying and analyzing the fuel are sufficient.

While the author does not make specific recommendations toward the improvement of accuracy it is quite apparent from the paper, although not brought out very strongly in the discussion, that the primary requirement is a test of reasonably long duration. No duration however long will eliminate all of the errors but every added hour of the run, assuming uniform care and attention, reduces the proportion of total error. The one big error in a boiler trial is made when it is too short. A 48-hour run is in several respects more accurate than the average of two 24-hour runs.

The so-called heat balance is too useful to give up, but perhaps it would be wise to state only the computed items and their total as representing the "heat accounted for."

There are altogether too many boiler tests made and a large proportion of them are perfectly useless for many purposes. As pointed out by Mr. Burke, studies of temperature and flue-gas composition often give more reliable information than the evaporation. The writer recalls the instance of a coal-feeding device, the only function of which was to spread buckwheat coal over the grate. The merit of the device could have been determined by an experiment made 100 miles from any boiler and the actual tests made by using the machine under a boiler indicated several interesting things but only incidentally the functioning of the machine. It is extremely illogical and unwise to use a steam boiler as a measuring instrument. It lacks every desirable characteristic of such an instrument. It is costly, inaccurate and subject to all sorts of disturbing influences to say nothing of the human factor which always enters into its operation.

New York, N. Y. W. D. ENNIS.

Test to Determine the Pressure Caused by Expansion of a "U"-Pipe Bend

TO THE EDITOR:

Recently the writer noted a request for information relative to the pressure exerted by the expansion of steam pipes when the pressure or strain due to the temperature is transmitted to the anchors.

Fig. 1 shows the method of test adopted by the writer to determine this. Preliminary calculations, however, were made as follows:

Pipe.....standard full weight,	4 in. diam.
Wall thickness.....	0.237 in.
Sectional area of metal.....	3.18 sq. in.
Length of pipe in bend.....	23 ft.

Area in half section = 3.18/2 = 1.59 sq. in.

Lever arm of pipe = Y = O. D./2 = 4.5/2 = 2.25 in.

Lever arm of bend = 7 ft. 2 in. = 86 in.

Limiting the stress to 16,000 lb. per sq. in.

$$\text{Pressure} = \frac{16{,}000 \times 1.59 \times Y}{\text{Lever arm of bend}} = \frac{16{,}000 \times 1.59 \times 2.25}{86} = 665.5 \text{ lb.}$$

This figure, however, does not disclose the number of inches of compression required to produce the stress which the test does show, as will be seen later.

The tensile stress in the pipe wall was calculated as follows:

		Sectional Area		Moment of Inertia	
O. D. = 4.5	Outside	=	15.904	I for O. D. =	20,129
I. D. = 4.026	Inside	=	12.75	I for I. D. =	12.948
	Difference	=	3.154	Difference =	7.181

Lever arm of bend..... 86 in.

Pressure to compress bend 2¾ in. from test . 580 lb.

Whence

580 × 86 = 49,880 in-lb.B.M.

and

$P = MY/I$ = (49,880 × 2.25)/7.181

= 15,630 lb. per sq. in. tension in the bend.

Fig. 1 shows the method employed in setting up for the test, which was as follows:

The bend was mounted on beam scales in such a way that only

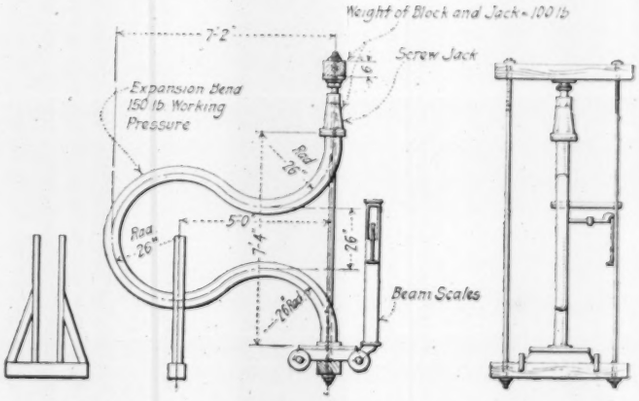

FIG. 1 TESTING DEVICE FO EXPANSION BENDS

the load on the bend would be measured. Compensation was made on weight arm for the weight of the pipe and jack.

The compression test data obtained were as follows: The bend standing on a flange compressed ¼ in., due to its own weight, (255 lb.) and it required a pull of 49 lb. to restore it to its length of 7 ft. 4 in. between flange faces.

100 lb. compressed bend ½ in. more, or ¾ in.
247 lb. compressed bend 1 in.
281 lb. compressed bend 1¼ in.
340 lb. compressed bend 1½ in.
431 lb. compressed bend 2 in.
580 lb. compressed bend 2¾ in., or to 7 ft. 1¼ in.

As it is usual to stretch a bend of this kind when drawing up on the flange bolts, it may be assumed that there is little or no stress on the anchors except when cold, and that it requires approximately the same stress to extend the bend an equal number of inches, although this may not be strictly true, on account of the tendency to cripple the pipe wall on the inner radius and stretch it on the outer when the bend is made.

These tests were also intended to indicate the stress under ex-

pansion limits if the pressure was later raised to 325 lb. per sq. in. and at a temperature corresponding to this pressure and 150 deg. superheat; barring a possible decrease in the bursting strength of the pipe due to the temperature, the bursting safety factor for this pressure will be nearly 8 for 4-in. pipe and a cold-water test.

Baltimore, Md. A. E. WALDEN.

An Engineering Education Question

TO THE EDITOR:

The science of engineering in its various phases is the most powerful actuating lever in the world today as pertaining to the progress of civilization and the unfolding of known and unknown forces which will serve mankind, to the end that life as men now know it will only be remembered in the future as a nightmare of misdirected energy, waste, lack of order, and greed.

With the foregoing thought in mind, and those set forth in papers presented before the A.S.M.E. by Prof. C. F. Scott, T. C. Pratt, A. G. Christie, J. E. Otterson, and Dexter S. Kimball, on the subject of professional engineering education for the industries, the writer here records some impressions of the subject from the broad viewpoint of how to make the science of engineering most active in all the work of the world, for we want not only good engineers, and many of them, but we want—and must have—more men in the world's business who can engineeringly focus.

If so, how are we to stimulate a desire for engineering knowledge in our young men, and in the end produce the men with engineering knowledge, and in sufficient numbers to weave the thread of engineering science throughout the fabric of civilization in a symmetrical and predominating pattern.

It would seem to the writer that control as applied by our educational institutions to engineering education is the answer. We then may ask:

What is a sane and safe latitude for the control of an engineering education from the beginning to the end? A latitude which engineers, employers of engineers, and the public, can safely subscribe to as a means to the end of producing for America and the world the engineers upon whom will fall the task of carrying on the great development and progress, which must take place in national, civic, industrial, commercial, and transportation life as men push on to the world's greater future?

What kind of a system will best serve the universities of our commonwealth, to the end that they shall have the greatest opportunity of developing the greatest number of inventive, research, and constructive engineers?

What attitude will the educator, the engineer, and man of business take toward a means to the end of giving this country and its associates the greatest number of men who know what engineering means, and who, while not active as engineers, will think and act along engineering lines because of an engineering education?

Will educators sense the fact that an engineering course with latitude educates a man better than those leading to a L.L.B., B.A., or B.C.L., or like degrees, because it fits him better for any line he may follow in business life, and because it is obvious that the more citizens a country has who can think engineeringly, the greater and more rapid will be its advancement?

From the opinions which are appearing in the educational and technical press, it would seem that the prevailing idea on the subject of engineering education is that the harder and less attractive an engineering course is made, the better engineer it will produce. If such is the idea to be conveyed, it is eerie.

However, it seems that the majority of educators and engineers who are interested in the subject to the extent that they have something to say upon it, feel that the best results can be accomplished in the engineering course that calls for increased pressure and period—the kind of course which is most attractive to the photographic-minded student, because under a system of pressure and period it would only be the photographic-minded student who could hope to make the entrance, go through the course and be graduated, while the young man who absorbs knowledge slowly would have great difficulty in even approaching a university campus. Be it understood, however, that students with photographic minds can be developed into real engineers.

Under the plan suggested for improving engineering courses in order to produce better engineers, there is no provision made for considering the young man who may carry in his mind the rarest engineering ability, which ability cannot be cultivated by a system that assumes that the phenomenon of memory is a satisfactory proof of creative and constructive ability. However, this ability could be cultivated by a system based on time, reasonableness, patience, and encouragement.

The educational institution that would multiply the barriers to its engineering course so that only the so-called select students or high-grade men can enter, and by such barriers keep out all low-grade men, and then follow with an inflexible six-year course of study, is not rendering to America its maximum effort for the general good of the nation, and can be said to have reached the exclusive stage in education.

It is a fallacy to assume that the student who can reel off the day's work in perfect synchronism with the instructions of the professor is to be the great engineer of the future, because such is not always the case, as is shown by the history of engineers, past and present.

It may be that our educators and the engineers they have produced are developing a conviction that the profession of engineering will become debased if it is made easy to attain, but this is not so, and any line of reasoning which advocates pressure and ambition-killing periods for the young mind is wrong—wrong from a standpoint of efficiency as demonstrated through an engineering education, because efficiency in engineering as applied to the work of the world will best be served by our universities educating, or partly educating, all of the young men that it is possible to induce to take up the study of engineering. In this way there will be produced not only the greatest number of real engineers from the greatest possible field of embryo engineers but also, from the men who are not suited for the life of a working engineer, a class of non-active engineers who will find their place in the commercial world. These men will be properly educated to understand what constructive advancement means, and will be broader and more aggressive citizens, better servants of the government, state and municipal, better bankers, manufacturers and merchandizers. Again because they will know enough of the laws of engineering to make them interested in the evolution of the world along engineering lines, they will be able to help their brothers, the highly trained and natural engineers, to put into practice their ideas and aims and push civilization on more rapidly to greater heights.

It is a well-known fact that many 95 per cent men have proven "dudds" on the battlefield of engineering, and that many, yes—a great many class tail-enders, or dropped-for-failure men have to their credit great achievements. The first individuals had the photographic mind while the latter did not, and according to the education specifications proposed, would not have been accepted as students; nevertheless they have been able to meet the working specifications of the world through what they did assimilate engineeringly, and because of this they have accomplished things of importance. And let it be remembered that there are some brilliant engineers with concrete works to their credit who were not university trained, so that there is some power outside the pressure-and-period course suggested.

It would, therefore, seem that the engineers and educators of today should view this all-important question not from the standpoint that we must deal only with the easily educated young man, but rather from the standpoint that we wish to develop for our country, and the world, the largest number of engineers within our power, that we want to make engineering a democratic line of endeavor, not an exclusive one. To do this we must use the keys of reasonableness and encouragement, leaving the initiative and ambition of the student to act as the medium through which he will gravitate to his true position in life.

Chicago, Ill. W. R. MACKLIND.

A Correction

On page 516 of the August issue of MECHANICAL ENGINEERING in Mr. T. A. Lewis's paper on Utilization of Waste Heat in the Steel Industry, the twelfth line should read "It amounts to $25,000 a year per furnace" instead of $2500.

MECHANICAL ENGINEERING

A Monthly Journal Containing a Review of Progress and attainments in Mechanical Engineering and Related Fields, The Engineering Index (of current engineering literature), together with a Summary of the Activities, Papers and Proceedings of

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Jurisdictional Board Asks Coöperation of Engineers

FOR over two years a quiet but effective body has been at work preventing misunderstandings that may lead to strikes in the building industry. These misunderstandings are not the major ones between the employers and the workmen but those insidious fallings out over work claimed by more than one building trade. In 1919, as the result of a plan adopted at the annual meeting of the Building Trades Department of the American Federation of Labor, a National Board for Jurisdictional Awards in the Building Industry was established. Coöperation of the contractors, architects and engineers was secured and as now organized this arbitration body is made up of three representatives of the labor unions, three representatives of contractors and employers of building-trade workers, a representative from the American Institute of Architects and one from the American Engineering Council.

The constitution and rules of procedure under which the Board has successfully carried on its work, provide, in the main, for the submission of complaints in writing through one of the organizations signatory to the plan, and a hearing after due notice to all parties in interest. A two-thirds vote of the Board is necessary for a decision, failing which, an umpire, whose decision is to be final, is selected either by the Board or the Secretary of Labor, although, thus far, it has not been necessary to resort to an umpire. Provision is also made for the appointment of committees to investigate cases that may be brought to the attention of the Board. Each of the labor bodies coming under the scope of the Board agreed that their membership shall not take up any sympathetic strikes in any case of jurisdictional dispute. Suitable penalties are provided for violation of this rule. Under the guidance of these principles the Board has considered a number of troublesome points of difference between the various building-trades unions and in general its findings have been regarded as final by the trade unions involved. In fact those who have been intimately connected with the workings of this Board are convinced that its accomplishments have fully justified its establishment. One prominent labor leader has expressed his satisfaction in a statement that the Board has accomplished more in the short period of its existence than the unions themselves in the years in which they have been joined in their Federation.

In only one instance has there been any organized attempt to obstruct the action of this Board. The carpenters refused to abide by the Board's award to the sheet-metal workers of the work of setting hollow steel doors, hollow metal window frames and sash. Great embarrassment resulted from the tactics pursued by the carpenters and as a result the carpenters' union was forced to withdraw from the Building Trades Department of the Federation. In a resolution, given in full in the June issue of MECHANICAL ENGINEERING, page 405, condemning the action of the carpenters' unions of the Building Trades Department in disavowing its decisions, the Jurisdictional Board called upon all parties to the plan to show an active support, the architects and engineers by inserting in their specifications and contracts a stipulation that the decisions of the National Board for Jurisdictional Awards in the Building Industry shall be observed, the contractors by similarly requiring coöperation from their sub-contractors and the labor men by disciplining subordinate bodies that are inclined to dissent.

The attitude of the Building Trades Department of the American Federation of Labor is most encouraging, especially as at the recent Cincinnati convention it unanimously voted confidence and support of the Board's work. Furthermore it refused to readmit the carpenters' union to the Department except in accordance with the constitution of the Jurisdictional Board. There is, however, a feeling among some of the labor men that the architects and engineers are rather luke-warm toward this movement to eliminate jurisdictional strikes and that some of the contractors, among whom are many of our engineers, are not giving their support whole-heartedly. As their contribution to the elimination of waste in industry and as part of their obligations to their clients and the general public, who ultimately pay the cost of strikes and other labor troubles, engineers, both as designers and contractors, should line up with the other parties to this voluntary agreement and support with all their strength the work of the Board and use every reasonable effort to secure the coöperation of their colleagues and associates.

We take this opportunity, therefore, to emphasize again the request of the Board for engineers, architects and contractors to insert in contracts the stipulation that the decisions of the Jurisdictional Board shall be observed, than which no more direct or effective method seems practicable. It is not uncommon at the present time for architects and engineers to incorporate in their specifications that disputes as to the meaning of those specifications shall be submitted to arbitration, and even in many cases to name certain individuals in the specifications as arbitrators. Why is it not fitting that the success and standing of the Jurisdictional Board be recognized in a similar manner in matters pertaining to jurisdictional disputes?

RUDOLPH P. MILLER.[1]

German Standards

THE writer had an opportunity to visit Germany a few months ago as a delegate of the American Engineering Standards Committee for the purpose of discussing international ball-bearing standards with the German Ball-Bearing Committee.

In this work I made the acquaintance of several of the leaders of the German standardization work and obtained an idea of the magnitude of this work in Germany.

It was only a few years ago that the "Normenausschuss der Deutschen Industrie," an organization corresponding to our American Engineering Standards Committee, was formed under the auspices of the Verein Deutscher Ingenieure, but the amount of work which it has accomplished since its formation is stupendous.

The "Normenausschuss" has already issued several hundred sheets of approved standards, and about twice as many are already published as proposed standards. This enormous output of the German organization has led many to believe that it was merely a factory, producing "paper standards," and that its work was not to be taken very seriously. A personal investigation convinced me that this is not the case, and I found that the great output of standards was merely due to the enormous efforts put forth and to the enthusiasm of the great majority of the interested parties.

[1] Representing American Engineering Council on the National Board for Jurisdictional Awards in the Building Industry.

This enthusiasm is due to a more or less general recognition, created under the pressure of war conditions, of the great economical value of standardization, and to the very generally accepted opinion that a standardized industry would be one of the strongest weapons in Germany's struggle for economic rehabilitation and financial reconstruction.

To give a concrete illustration of this point, I may mention that at the time of my visit, a syndicate of nineteen German and one Swedish manufacturer was executing an order for seven hundred locomotives for Russia, all of the same design, and every part in every one of them was being made interchangeable with the corresponding part in all the others, all parts having been manufactured to the same fits and tolerances. This feature will have the great advantage of permitting the Russian railroads to use any disabled locomotive as a store of spare parts for all the others. In case of future orders, the Russians will no doubt specify that all new locomotives of this class be built not only of the same design as above, but so that every part is interchangeable with the above.

Another error in our conception of German standardization is that the "Normenausschuss" is autocratic in its methods and is not in as close contact with the industries as our own standardizing bodies. I found, on the contrary, that absolutely the same methods are used there as here to arrive at national standards. The staff of the "Normenausschuss" is merely coördinating and directing the work of the various committees, and the actual establishment of standards is left to recognized leaders in the various industries.

The work of the permanent staff is greatly facilitated by the eager response from German industry, whose leaders look to standardization as one of their greatest hopes for salvation. Many of the big German manufacturers have standard departments of their own, with a number of engineers and draftsmen working permanently on national standards.

It would of course, be highly desirable to establish international standards and great efforts are being made to obtain them in certain lines, such as ball bearings. One of the greatest obstacles for international standardization, however, is the fact that America and England do not commonly use the same scheme of measurement as other countries.

There is no doubt in my mind that one of the main reasons why forward-looking Germans force their standardization work is because they want to impress German standards on the great import countries and possibly on the whole world. Holland, Switzerland, Austria, Sweden and many other European countries follow the German lead very closely. The great German deliveries in kind to France will no doubt, as far as feasible, be made according to German standards, thereby introducing them in that country.

The days may not be far distant when our manufacturers will receive inquiries from oversea countries to furnish goods according to the national German standards or specifications, as referred to above in connection with the Russian locomotives, and it behooves us to plan in time to meet such conditions. England seems to have fully realized the importance of recognition of her standards, and is trying to force the adoption of them in her colonies and dominions.

Another institution closely connected with the "Normenausschuss" deserves special mention, and that is the Committee on Industrial Processes. This committee investigates the methods used in the various industries to obtain certain results, submits them for critical comparison and standardizes the best obtainable methods. This committee, which is also sponsored by the Verein Deutscher Ingenieure, works of course in very close coöperation with the "Normenausschuss."

On account of its very efficient organization, the German "Normenausschuss" has come to play a more important role in the industrial life of the nation than originally expected. Manufacturers write to it for advice on questions of the most delicate nature, and frequently competitors exchange manufacturing secrets through some member on its staff.

In conclusion I wish to express the hope that the example of the German engineers and manufacturers may spur us to make equally large contributions in work and money to the cause of standardization, and that our leading engineers may try to realize the enormous economical importance of both national and international standards.

OSCAR R. WIKANDER.

Beneficial Effect of Prizes

THE A.S.M.E. Committee on Awards and Prizes has been asked to write briefly as to the benefit to the Society and to Engineering of the prizes and honors which are in the gift of the Society, with the idea that it might possibly arouse greater interest in the subject and induce a larger number to compete for these awards.

The idea of the award of a prize for the greatest merit must be practically coeval with the race. Not many of us as engineers have read the poem in the original, but we all know that one of the greatest of the world's poems, the Iliad, was in a way the result of the award of a prize in a beauty contest. Leadership in savage tribes is the reward for supremacy in bravery, skill at arms or wisdom, and so we might go on indefinitely. In other words, the feeling seems thoroughly implanted in human nature that some tangible evidence of recognition of superiority is of great value in helping to bring about that superiority.

In considering the award of prizes by our Society there comes to mind the story told of Herbert Spencer, the great philosopher (who was at first an engineer), which, whether true or not, is worthy of very careful consideration. It is said that after he became famous and was recognized as one of the world's greatest philosophers, the universities of Oxford and Cambridge offered to confer on him the honorary degree of Doctor. The story goes that Spencer's reply was that, when he was a young man and struggling hard to get recognition for his work, and when such degrees from the universities would have been of great value to him, they were not forthcoming; now that he had attained a certain degree of fame without their help he objected very decidedly to having the universities plaster their label on him after all the rest of the world had already assigned him a definite position. Observation of the honorary degree lists of our own great universities would lead one to believe that in general they follow the same plan as the English universities followed with Spencer. In other words, after a man has become famous then the universities acknowledge that fact by giving him a degree. Nevertheless Spencer's declination of the honor is about the only one on record.

This does suggest, however, that the Society might very well take the lesson to heart, and endeavor to ascertain meritorious work whether the individual is already well known or not, and that in the case of previously unknown men this award of approbation would have a real value, and might, in many cases, be such an encouragement as to lead to work of the highest value later on in life.

In order that this may be the case it is necessary that all the members of the Society should take an interest in the subject, familiarize themselves with the awards which are provided and assist the Committee on Awards and Prizes by friendly suggestion, where they are not competitors themselves, and by doing their own very best work where they feel that their efforts may justly entitle them to consideration.

An annual prize is for the best paper appearing in the Society's Transactions during the year. These papers cover so wide a range of subjects that it is impossible for a single committee unaided to make a decision based on expert knowledge of these many subjects. If the members who specialize in any particular subject find a paper along their specialty which commends itself to them as of very high value it would be a favor to the Committee and helpful to the Society if they would write to the Secretary's office giving their opinion, together with the reasons for esteeming it of specially high value. The Committee can then be trusted to weigh the evidence in the various cases and make a decision, taking account of all the features which enter in such a competition, with the probability that the paper finally decided upon is undoubtedly the best of all which appeared.

With respect to the medal for specially meritorious inventions or work in engineering, it may well happen that some members may know of such cases, which, unless they advise the Committee about them, might pass unnoticed. This was exactly the case with the first award of this prize. Those who knew of the work of Mr. Carlson recognized that it was of extreme value to the country in its hour of trial and that it solved a problem which otherwise would have involved immense cost and difficulty.

The Committee believes that much greater honor will accrue to the Society from the discovery of highly meritorious work of obscure

or little-known members, rather than from conferring the prize on some famous men whose work has been heralded in the daily press until it is known to every bright schoolboy.

The Committee on Awards is willing to do a great deal of work and give its very best efforts to advancing the interests of the profession in making suitable recommendations, but it lays no claims to omniscience and must have the cordial coöperation of the membership at large if the great benefits which will result from the proper award of the prizes is to be secured.

WALTER M. MCFARLAND.[1]

Alfred D. Flinn Reports Nationwide Interest in Research

Alfred D. Flinn, secretary of the Engineering Foundation and chairman of the Division of Engineering of the National Research Council, returned August 2 from a six-weeks' tour to the Pacific Coast on which he addressed groups of engineers to enlist their aid in a nationwide plan for engineering and industrial research.

Mr. Flinn addressed meetings at Salt Lake City, Los Angeles, San Francisco, Sacramento, Portland, Oregon, Seattle, Duluth and Minneapolis. In spite of the fact that the time of year was such that the men of the profession were to a large extent scattered, a group of from fifty to seventy-five representative engineers were present at every meeting. The meetings were arranged by local sections of the National Engineering Societies, or the local engineer's club, and the audiences included officers and members of these Societies as well as others interested in problems of research.

There was evidence of interest everywhere in the work of the Engineering Foundation and the National Research Council. Men were impressed by the extent and quantity of the work already done, considering the limited resources of the Foundation, and desirous of having the work pushed further so they could have the benefit of it. The Engineering Societies Library received favorable comment for the splendid service it renders to engineers.

At Los Angeles, San Francisco, Seattle and Portland Mr. Flinn found particular interest in the proposed study of arched masonry dams. In the first three of these cities there was an active interest in the marine-piling investigation being conducted by the National Research Council. In this connection, during Mr. Flinn's time in Canada where he met and talked with individuals instead of groups, he met Prof. C. McLean Fraser of the Biological Board of Canada. Professor Fraser gave assurance of his desire to coöperate in the study of marine borers and estimated that the damage done by these small animals to the wooden piling along the British Columbia Coast alone amounts to several hundred thousands of dollars every year.

One object of the trip was to make personal contacts that might lead to interesting people of means in contributing to the support of the Engineering Foundation. Engineers themselves are not able to do this and contributions must come largely from outside sources. Personal contacts were also made with men who can be useful in committee work and who have shown a desire to help.

St. Louis Central Station to Use Pulverized Fuel

Mechanical engineers who have been following the performance of the powdered-fuel installation at the plant of the Milwaukee Railway and Light Company will be very much interested in the announcement that the new Cahokia plant of the Union Electric Light and Power Company, St. Louis, Mo., is also to have a pulverized-fuel installation.

In a statement recently issued, McClellan and Junkersfeld, Inc., engineers and constructors of this project, emphasized the fact that in the Cahokia plant pulverized-fuel equipment will permit the economical use of the low-grade Illinois coal having a heat value of approximately 10,000 B.t.u. per pound and high moisture and ash contents.

The decision of the engineers was reached after extensive tests and investigation on stokers and pulverized-fuel equipment. The plant at Milwaukee afforded an excellent opportunity for the investigation of performance with powdered coal and it placed the results on a basis comparable with those secured with the best modern automatic stoker plants.

The new plant, of which 60,000 kw. will probably be in operation next year, will have an ultimate capacity of 240,000 kw., and is to supply the rapidly increasing industrial and lighting load in St. Louis, in addition to that now being supplied from the Keokuk Dam and from an existing large steam plant.

The engineers state that improvements may be expected in the development of stokers as well as in pulverized-fuel equipment but that stokers have been under development for a long period of years, and the burning of coal in pulverized form in large quantities by central stations has been done only in the last few years. Without attempting to estimate future developments in the two classes of equipment for burning coal at least the present relative position, so far as the Cahokia Station is concerned, will probably be maintained.

The engineers call particular attention to the fact that their recommendation should not be applied to any other quality or price of fuel, plant site, plant layout, load factor or other conditions without making careful adjustment for the differences between such conditions and those which obtain with the Cahokia Station.

Two 30,000-kw. turbines, eight 1800-hp. B. W. boilers without economizers and a Lopulco system for burning pulverized fuel will be installed. The plant will be located on the Illinois side of the Mississippi River about fifteen miles from the coal mines.

DeLamater-Ericsson Collection to be Nucleus for National Museum of Engineering

At the Council Meeting in Atlanta on May 8, President Kimball announced the appointment of five A.S.M.E. representatives on the Joint Committee on the DeLamater-Ericsson Historical Collection. The personnel of the Joint Committee is as follows:

American Society of Mechanical Engineers: H. F. J. Porter, Chairman of the Committee, Sydney Bevin, Fred A. Halsey, Thos. F. Rowland, Jr., Henry R. Towne; Swedish Societies of New York: Axel S. Hedman, Johannes Hoving, Charles K. Johansen, Emil F. Johnson, Ernst Ohnell; Associated Veterans of the DeLamater Iron Works: Walter M. Parker. This Committee will collect the historical material connected with Cornelius H. DeLamater and Capt. John Ericsson during their fifty years association as the leading factors of the DeLamater Iron Works.

In the concluding paragraph of the Report of the National Museum at Washington for 1920, attention is called to the fact that "the commanding place in the world which the United States has reached in the short space of seventy-five years is due largely to the full development and utilization of mechanical power in the exploitation of her natural resources. It is this that has made it possible for the people of the United States to enjoy a standard of living far and above that under which the peoples of the rest of the world exist, and still no public sign of appreciation, either national or otherwise, is to be found anywhere. What more suitable monument could there be than a Museum of Engineering and where could there be found a more logical place for it than as a part of the great National Museum?"

The Smithsonian Institution then not only solicited the placing of the DeLamater-Ericsson Historical Collection in its National Museum but proposed the coöperation of the Committee in establishing the nucleus there of a great national engineering museum comparable to the foreign museums to record the accomplishments, in the upbuilding of this nation, of its engineers. The DeLamater-Ericsson Historical Collection will be exhibited first at the Annual Meeting of the Society in December. Later such part of it as will exhibit the contribution to civilization by the Swedish-American engineer, Captain Ericsson, will be sent to Sweden to the Tercentenary of Gothenburg to be held there from May to September, 1923. On its return, the whole collection will be placed in its permanent repository in the Smithsonian Institution in Washington, as the nucleus for the Engineering Section of the Museum.

It is desired to make this a national movement in which every engineer in the country will participate. Engineering societies and alumni associations of engineering schools are requested to communicate for further information with the Joint Committee on the National Engineering Museum, 29 W. 39 St. New York, N. Y.

[1] Chairman of the A.S.M.E. Committee on Awards and Prizes.

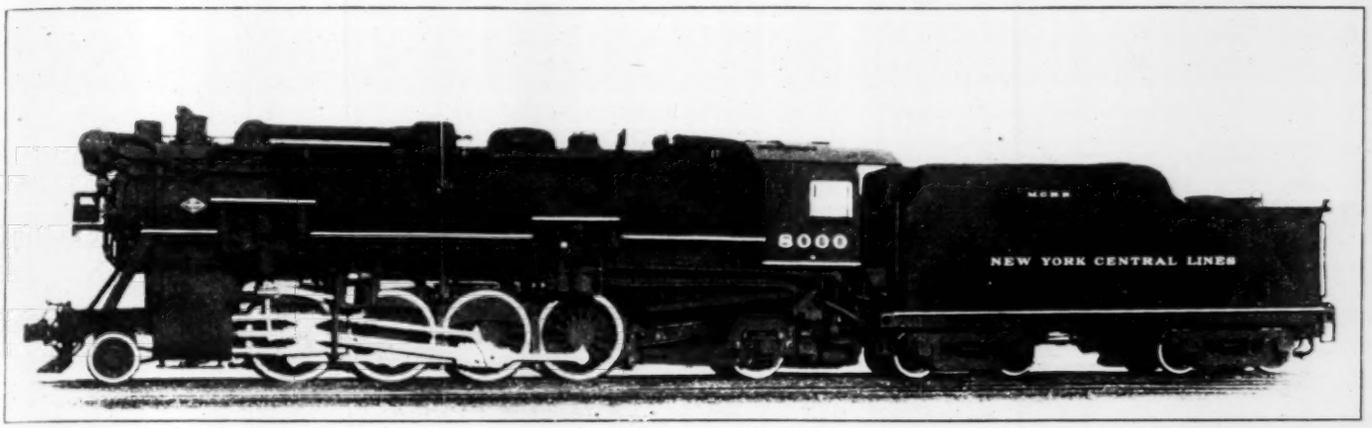


Fig. 1 The Novel Attachments, Shown Above, Contribute to Economical Operation

Remarkable Steam Locomotive Sets New Standard

Mikado for Heavy Fast-Freight Service on the Michigan Central Embodies New Devices and Principles That Insure Light Weight and High Economy

REGARDLESS of the gesture threatening electrification of railroads sometime in the future, the development of steam locomotives goes merrily on. The most recent example of remarkable progress is a new Mikado placed in heavy fast-freight service on the Michigan Central a little over two months ago. This machine embodies the results of a score of years of study and research and although no official tests have been taken, the performance has been so satisfactory that the order has been placed for one hundred and fifty according to the same detail specifications. In its initial road test, it hauled 100 heavily laden coal cars and later pulled a train of 140 cars containing more than 9000 tons of coal, this over the level division between Toledo and Detroit.

"No. 8000," as this extraordinary engine is designated, was built by the Lima Locomotive Works according to designs made under the supervision of President A. H. Smith of the New York Central Lines. To obtain a drawbar horsepower for the minimum fuel, weight and cost of repairs and to secure ease and safety of operation, the best known practices and devices have been incorporated.

The first requirement of maximum tractive effort for the minimum weight is an elimination of unnecessary weight and this has been accomplished, without sacrifice of strength, by refinements in design and by the use of alloy steels and hollow axles and crank pins. Without tender, the locomotive weighs 334,000 pounds The tender with its capacity of 10,000 gallons of water and 16 tons of coal, weighs 199,700 pounds. Maximum tractive effort of 74,500 pounds is obtainable, a booster on the trailer truck delivering 11,000 pounds. In a statement issued by the New York Central Lines, quoted recently in the *Railway Age*, attention is especially directed to the fact that, comparing No. 8000 with the heaviest Mikados in the Michigan Central service, No. 8000, with an increase in weight of only two per cent, has an increased tractive power of nearly eight per cent from the forward cylinders alone and with the booster cut in the increase is 26 per cent.

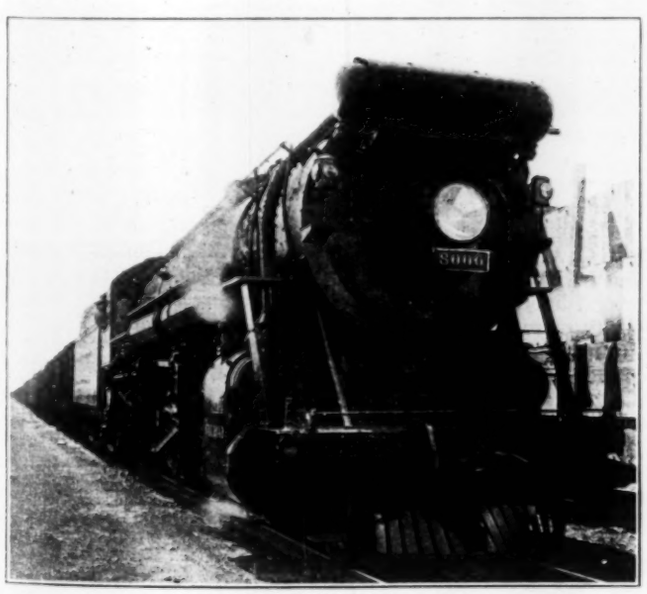


Fig. 2 The Feedwater Heater is Prominent

Perhaps the most noticeable change in this locomotive to achieve greater economy in fuel consumption is the addition of a feedwater heater. In the use of superheated steam a departure from common practice is the location of the throttle between the superheater and the cylinders and the use of superheated steam in the air pump, feedwater pump, booster engine and headlight turbo-generator. In Fig. 1 the dry pipe can be seen leading forward for connection with the superheater. The throttle box is ahead of the stack, an arrangement necessary for the use of superheat in the auxiliaries. A double arch, with eight supporting tubes, increases the effectiveness of the fire and improves the boiler circulation.

The feedwater heater is installed at the front of the engine over the headlight, high enough to return the condensate to the filter in the rear of the tender. The feedwater pump is shown on the left side of the locomotive. The boiler pressure is 200 lb. per sq. in. and the superheat at the cylinder is over 550 deg. fahr. The Type E superheater, using superheater tubes in every boiler flue, was applied. The cylinder diameter is 28 in. and the stroke is 30 in.

The cab design is such that the enginemen perform their duties with the minimum of movement and practically no physical effort. Precision power reverse gear, an Elvin stoker and a power grate shaker are installed for this purpose. The whistle is operated pneumatically. There is a water scoop on the tender.

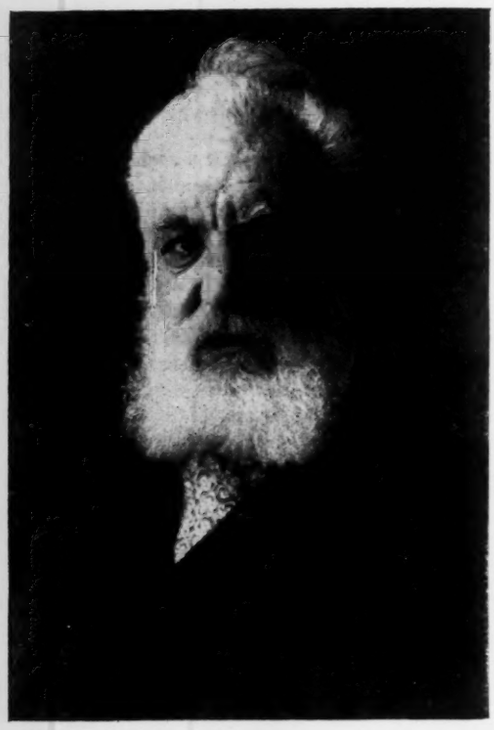
For many years, the development of steam locomotives was in size and weight but without systematic improvement in the making and using of steam. With the adoption of superheat, economy of operation was greatly improved but steam-locomotive design is still under great pressure to meet rigid requirements with definite limitations of size and weight and at the same time to equal the best results of marine and stationary practice. In this respect No. 8000, an embodiment of devices not new or radical, sets a new standard. Further, the elimination of weight and the refinements of design will lessen the dynamic augment

Steam locomotives must bear the burden of transportation in this country for some time to come and the development of this machine is a courageous movement toward better practice. The old rule demanding simplicity above all seems to have been discarded.

Alexander Graham Bell, Father of the 'Phone, Dies

ALEXANDER Graham Bell is dead. In the early morning of August 2, 1922, the great inventor passed quietly away at his summer estate in Nova Scotia. At sunset a few days later his body, clad in a homely tweed and corduroy suit similar to the one he wore in his laboratory, was laid to rest at the peak of Beinn Bhreagh Mountain overlooking the beautiful Bras d'Or lakes on whose waters he had experimented with speed boats and fast water sleds.

The inventor of the telephone was born in Edinburgh, Scotland, March 3, 1847. His grandfather, Alexander Bell, invented a system for overcoming stammering, and his father, Alexander Melville Bell, dean of British elocutionists, perfected a system of "visible speech" by which the dumb could speak. Young Bell was educated at Edinburgh and London where he acquired a smattering of music, electricity and telegraphy. His chief interest lay in the



ALEXANDER GRAHAM BELL

study of sound, and at the age of sixteen he was teaching elocution in the British schools and instructing deaf mutes.

At twenty-two Bell was threatened with tuberculosis, a disease which had claimed his two brothers. His whole family migrated to Canada in 1870 and the next year he went to Boston University as professor of vocal physiology. His system of teaching deaf mutes won immediate recognition and his success encouraged him to open a school of his own. He went to live at the home of one of his pupils in Salem, and it was in the Sanders cellar after school hours that he started a series of inventions that were to culminate in the telephone.

In the winter of 1874, at an electrical workshop where he had taken his "harmonic telegraph," a device for sending a number of Morse messages over a single wire at the same time, Bell met Thomas A. Watson, who was employed there. From that hour Watson devoted most of his time to working out in brass and iron the ideas that came pouring out of Bell's brain. The two young men labored day and night in the workshop and in the Sanders cellar in Salem to demonstrate Bell's dream that an electric wire could carry the sound of the human voice. They worked while sane men gaped at them in pity.

In June, 1875, after months of experiments on the harmonic telegraph, something happened to convince Bell that at last he was on the right track. One of the transmitter springs of his telegraph instrument stuck, and the magnetized steel generated a current that sent a faint noise over the electric wire to Bell's receiver. This was the necessary proof that his principles were correct. Thereafter it was a question of working out details. On March 10, 1876, at a Boston boarding house, Bell, from his room on the top floor, spoke to Watson in another room, and Watson heard what was said. A week later Bell took out his first patent on the telephone.

The invention of the telephone was unique in a special sense in that it had not even been foreshadowed before its achievement. In later litigation on the Bell patent, the literature of the world was searched without finding a hint that anyone prior to Bell had even a vague thought as to how the electric transmission of speech could be effected. Possibly it was just this very fact that threw such stupendous financial difficulties in the way of the young inventor. The press reflected universal scepticism, and funds ran low for many months.

The story of the exhibit of the telephone at the Philadelphia Centennial Exposition on the day set aside for "freak novelties" has often been told, but not always in quite the way that Bell himself told it. According to Frederick P. Fish, former president of the American Telegraph and Telephone Company, to whom Bell repeated the story, the exhibit of the telephone created little attention. The various freak novelties were to be presented in order and the telephone appeared far down on the list. Sir William Thompson (Lord Kelvin) was to be present at the exhibition, and Bell was much excited at the prospect of having this eminent scientist see his invention. However, on the day of the exhibit, Sir William was delayed until it became so late that Bell thought his golden opportunity had been lost.

Finally Sir William came, and with him Dom Pedro, the Emperor of Brazil, a man of high attainment and very much interested in every phase of scientific work. Although Dom Pedro had once met Bell in connection with his work in teaching the dumb, Bell had no idea he would be remembered. But Dom Pedro grasped him cordially by the hand and when told of the invention of the telephone, asked to have it exhibited first of all. Both Sir William Thompson and Dom Pedro were greatly impressed and their outspoken enthusiasm went a long way toward attracting favorable attention to offset the universal scepticism of the public.

It was not until August, 1877, when there were 778 telephones in use, that the "Bell Telephone Association" was formed. Bell, Watson, Bell's father-in-law Gardener G. Hubbard, and Thomas Sanders, in whose cellar the invention was first started, were the members of the Company. Sanders was the sole financial backer. Bell was no business man, and after 1877 he had little active connection with the organization of the telephone industry. He married in that year one of his former pupils, went abroad to help introduce the telephone in England, returned, and with characteristic energy turned to experiments with flying machines.

Bell's inventions other than the telephone include the photophone, the induction balance, a telephone probe for the detection of bullets in the human body (for which he received an honorary M.D. from Heidelberg University at its 500th anniversary) and, with C. A. Bell and Sumner Taintor, the graphophone. It was his practice to keep complete records of his scientific researches, and the several hundred volumes containing these records cover a multiplicity of subjects from the utilization of waste heat to notes on eugenics and the biological history of a cat.

Dr. Bell had received many honors. In 1880 the French Government gave him the Volta Prix, and the engineering profession acknowledged his genius by bestowing the John Fritz Medal in 1907. He had received gold medals from The London Society of Fine Arts, the Royal Albert, the Elliott Cresson, and the Hughes Medal of the Royal Society of Arts. He was an officer of the French Legion of Honor. He founded and endowed with $250,000 the American Society to Promote Teaching of Speech to the Deaf. He was at one time President of the National Geographical Society, and was a member of the National Academy of Sciences, the American Philosophical Society, the American Academy of Arts and Sciences, and the American Association for the Advancement of Science.

The Treasure House of Aeroplane Design

McCook Field to Establish Museum of Aeroplanes and Aircraft Engines

ONE of the greatest difficulties encountered by designers of aircraft engines and aeroplanes lies in the inability to secure concise information about the various details of design. For example, the usual printed descriptions of an aeroplane engine tell about the number of cylinders, their dimensions and such main features, but when it comes to the exact location of the valves and the design of the cams, they are usually silent or indefinite. Even an inspection of the engine does not help in many cases as the desired part may be concealed from view and can be carefully studied only after the engine is dismantled. This cannot always be done for the sole benefit of the prospective designer.

The authorities of the Air Service, War Department, at McCook Field, took steps to remedy this situation for the benefit of their own engineering department as well as for legitimate use by other American engineers and manufacturers. During the war, through various agencies of the government, quite a collection of aeroplane engines of American, Allied and enemy origin was assembled at McCook Field, and this collection is to form the nucleus of the Museum of Aircraft Engine and Aeroplane Design now being installed in several hangars on the field.

The great value of this collection at McCook Field lies in the method of display adopted in place of the impressive but not always enlightening method of erecting engines on stands. Two engines have been secured for every type and one engine is placed on the stand completely assembled which gives a clear idea of

FIG. 1 A DISASSEMBLED ENGINE IS PLACED IN THE CABINET

its general construction and assembly. The other engine is entirely disassembled, the various parts being placed either in glass cabinets where they can be easily inspected and if necessary reached, or on shelves under the glass cabinets, these shelves containing mainly duplicate and very large parts. The designer, therefore, can easily inspect and measure any part of any of the engines shown in the Museum. There is no doubt that a few days spent in the Museum would give more information as to current practice in aircraft-engine and aeroplane design than could be obtained by any other means except extensive trips through the whole of Europe and the United States and visits to the factories. In a pocket by the side of each cabinet are placed printed descriptions, tracings, diagrams and such information as is available about each engine or plane. In addition any visitor who can show legitimate interest in this subject will be granted access to the bibliographical index files of the Engineering Division, McCook Field, in itself a veritable mine of information, often to be found nowhere else.

As it is impossible to apply the same method to aeroplanes on account of lack of space, somewhat simplified arrangements will show such details as construction of wings, landing gear, etc.

One of the most gratifying features of the McCook Field Museum is that there is no intention of making it a departmental preserve.

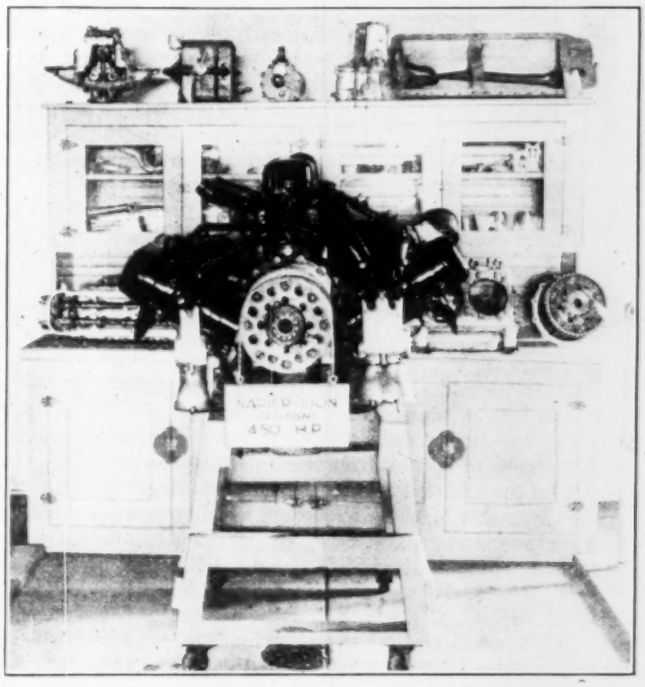


FIG. 2 THE ENGINE AND CABINET ARE AVAILABLE TO AMERICAN DESIGNERS

On the contrary, every facility of the Museum will be thrown open to any American engineer or manufacturer who can show a legitimate interest in this subject. Work is now proceeding on the construction of the cabinets and stands, and it is expected that the Museum will be opened the latter part of September.

Carbon Tetrachloride for Electric Fires

Engineers who look to the carbon tetrachloride fire extinguisher as the reliable aid in case of electric-arc fires will be interested in the recent report of the Bureau of Mines which acquitted the carbon tetrachloride extinguisher of the charge that the gases originated in the extinguisher caused the asphyxiation of a number of passengers in a New York City subway fire on July 6. A short circuit caused the fire in an express train on the Lexington Avenue Subway. The passengers were removed without casualty although it was necessary to take a number to hospitals so that they could be revived from the effects of fumes caused by the fire. At first it was thought that the carbon tetrachloride with which all subway trains are equipped caused the asphyxiation. The Report of the Transit Commission, which was assisted by the experts from the Federal Bureau of Mines, stated that the symptoms of the patients as shown in the hospital records can all be accounted for by the known effects of gases resulting from the burning of insulating materials such as rubber, varnish and paint, and that the symptoms given are not characteristic of phosgene or carbon tetrachloride poison. Furthermore, the Report states that carbon tetrachloride is a standard fire extinguisher in general use, approved by the National Board of Fire Underwriters and is particularly adapted for fires produced by short circuits in electrical equipment and apparatus because it is a non-conductor of electric current.

Engineering and Industrial Standardization

Fire-Hose Couplings

A NUMBER of conferences which have been held during the past two months have added new impetus to the campaign for an American Standard Fire-Hose Coupling. As far back as 1873 the importance of a universally adopted fire-hose coupling in the elimination of fire waste was recognized by those most directly connected with fire fighting.

At conventions of fire chiefs and the International Association of Fire Engineers this subject, received much attention, and finally a set of standard dimensions for the $2^1/_2$-, 3-, $3^1/_2$- and $4^1/_2$-in. couplings were agreed upon. In these early discussions the National Fire Protection Association, the New England Water Works Association, the American Water Works Association, and the National Board of Fire Underwriters took an active part. Later The American Society of Mechanical Engineers and the Bureau of Standards reviewed the work of the earlier committees and approved what was then generally known as the National Standard. The A.S.M.E. Committee's report was published in 1913 and the Bureau of Standard's Bulletin No. 50 appeared in 1914. Since that time a painstaking and consistent effort has been made by the National Board of Fire Underwriters to encourage the adoption of this standard coupling by the cities and towns of the United States. For those which had previously adopted a coupling whose pitch and outside diameter were slightly different from the standard this Board arranged for the development of a set of standardizing tools by a well-known firm of tap and die makers.

The Progress Report of the National Screw Thread Commission placed a stamp of approval on this fire-hose standard and completed it by the addition of a set of manufacturing tolerances. It was the discussion of these tolerances which was the immediate reason for the recent conferences. An agreement has been reached between the representatives of the National Board of Fire Underwriters, the National Screw Thread Commission, and The American Society of Mechanical Engineers. So it will probably not be long before the manufacture of standard fire-hose couplings will be placed on an interchangeable-production basis by the use of steel working gages which can be certified to by the Bureau of Standards.

It is proposed to present this standard in the near future to the American Engineering Standards Committee for approval as an American Standard.

Four New American Standards

Recent actions by the American Engineering Standards Committee have resulted in the following Standards:

Safety Code for Foundries

This Code is a revision of that developed by the American Foundrymen's Association and the National Founders Association, joint sponsors of the new code. The revision was worked out by a thoroughly representative Sectional Committee organized under the Rules of the American Engineering Standards Committee and included four representatives of makers and owners of foundry equipment, four of governmental bodies, two of technical associations, two of insurance organizations, and a representative of foundry employees.

This new *tentative* American Standard Code No. 20 deals with foundry conditions only, omitting such subjects as building construction, exits, stairways, elevators, lighting, sanitation, etc., as these subjects are covered by other Safety Codes which have an official status before the American Engineering Standards Committee. The code consists of 124 sections which are grouped under the following twelve main divisions: entrances, floors, pits, and galleries, gangways, aisles, foundry equipment, finishing and cleaning, heating, ventilation, operating rules, protection devices, employment of females, and recommendations.

The Sectional Committee which revised the foundry safety code and recommended it for approval by the A.E.S.C. included representatives of the National Founders Association, the Association of Government Labor Officials, the U. S. Department of Labor, the American Foundrymen's Association, the National Association of Mutual Casualty Companies, the National Safety Council, the U. S. Bureau of Standards, the National Association of Manufacturers, the National Bureau of Casualty and Surety Underwriters, the American Society of Safety Engineers, and the U. S. Public Health Service.

National Electrical Safety Code

The National Electrical Safety Code of the Bureau of Standards which covers the generation, distribution and utilization of electricity for power, light and communication has been approved as American Standard No. 21.

In making public this decision, the Standards Committee announces that there is now in process of formation a thoroughly representative Sectional Committee to consider any revisions of Part 2 of this Code, Rules for the Installation and Maintenance of Overhead and Underground Electrical Supply and Signal Lines, which may be deemed necessary by any of the interested parties. There are also being organized three sub-committees to take up the unification of crossing specifications under the three following heads: Signal Lines Crossing Railways; Power Lines Crossing Railways; and Power Lines Crossing Signal Lines.

It is believed that this action, together with the organization of the representative committees to take care of the revision of the Code and to prepare the crossing specifications, constitutes one of the most important steps yet taken in securing national uniformity in these matters.

Illuminating Engineering Nomenclature and Photometric Standards

This group of Standards as published by the Illuminating Engineering Society in 1918 has been approved as American Standard No. 22 with the substitution of six internationally agreed upon definitions for certain ones of the 1918 rules. The definitions which have been reworded are: luminous flux, luminous intensity, illumination, candle, lumen, and lux.

The special committee of the American Engineering Standards Committee which examined the proposal submitted by the I.E.S. and which recommended approval of the nomenclature and photometric standards included representatives of the U. S. Bureau of Standards, the American Gas Association, the American Physical Society, the International Acetylene Association, the Optical Society of America, the American Institute of Electrical Engineers, the Illuminating Engineering Society, and the National Electric Light Association.

Specifications for Testing and Use of Permissible Explosives Approved

The specifications for the testing and use of permissible explosives submitted to the American Engineering Standards Committee by the U. S. Bureau of Mines has been approved by the A.E.S.C. as an American Standard. It therefore becomes American Standard No. 23.

The Special Committee of the A.E.S.C. which examined the proposed specifications and recommended them for approval by the Standards Committee included representatives of the U. S. Department of Interior, the American Mining Congress, the Coal Mining Institute of America, the Mine Inspectors' Institute of America, the American Society of Civil Engineers, the Institute of Makers of Explosives, and the U. S. Department of Agriculture.

Your Comment is Requested

Stacks. Some of our readers have proposed the standardization of the specifications on which the estimates for circular brick stacks are based. A few of the items which might be specified are: maximum wind pressure, maximum permissible stress in brickwork, amount of lining, etc. Should steel stacks also be considered?

Valves, Cocks and Faucets. During the past two months the American Engineering Standards Committee has carried on a considerable amount of correspondence with a view to determining

whether or not these products offer a field for standardization and, if so, what dimensions should be considered. The Committee needs all the guidance it can have.

Shop Drawing Sizes. Periodically the A.S.M.E. Standards Department receives an inquiry concerning the supposed A. S.M.E. standard sizes for shop drawings. There are no such standards but many firms have given considerable attention to the problem. Should this information be collected and studied by a properly organized committee for the purpose of developing a set of generally acceptable standard sizes?

BOOK NOTES

BELEUCHTUNG DER BAHNHOFE UND DER BAHNHOFSHOCHBAUTEN. By Richard Sarre. Wilhelm Engelmann, Leipzig, 1922. (Handbuch der Ingenieurwissenschaften, 5. Teil, 5. Band.) Cloth, 7×10 in., 300 pp., illus. 154 M.

The primary object is to provide a discussion upon the principles and systems of lighting railway stations and railway office buildings. But since every existing method of lighting has been used for these purposes and since the principles of artificial lighting are of general application, the book is in reality a concise survey of methods of illumination and of the laws governing their use.

LES COLLOIDES. Par J. Duclaux. Gauthier-Villars et Cie, Paris, 1922. (Actualités scientifiques.) Paper, 5×7 in., 305 pp. 10 fr.

This work does not purport to be encyclopedic. It is, rather, a concise statement of chosen facts woven into a coherent account, from a single point of view, with useless details and superimposed theories avoided. Certain modifications have been made in the new edition. The author is Director of the Laboratory of the Pasteur Institute.

MATHEMATICAL THEORY OF PROBABILITIES. By Arne Fisher. Second edition, enlarged. The Macmillan Co., New York, 1922. Cloth, 6×9 in., 289 pp. $5.

The author's aim has been to treat all the modern researches upon this important branch of applied mathematics from a common point of view, based upon the mathematical principles laid down by Laplace, and to present a theory of probabilities as developed in recent years of value to the practical statistician, the actuary, the engineer and the biologist, as well as students of mathematics. The second edition is extended to nearly twice its original size by added chapters on frequency functions and their applications. Mr. M. C. Rorty contributes an introductory note indicating some of the practical applications of the theory of probabilities to business problems.

LES PROGRÈS DE LA MÈTALLURGIE DU CUIVRE. Par Auguste Conduché. Masson et Cie; Gauthier Villars et Cie, Paris, 1922. (Encyclopédie Léauté.) Paper, 5×8 in., 254 pp., illus., 14 fr.

Considerable progress has been made in recent years in the metallurgy of copper, due in part to the technical improvement of machinery and plants, but still more to scientific investigation and to the careful utilization of the chemical reactions that occur. This book is a concise account of this progress. It provides a statement of present knowledge of the properties of copper, the effects of impurities, its alloys, and the methods of smelting and refining, with careful attention to scientific principles and to the economic factors. It also presents a typical example of the value of systematic research and scientific methods for the development of an industry.

ON THE ELECTRO-DEPOSITION OF IRON. By W. E. Hughes. H. M. Stationery Office, London, 1922. (Dept. of Scientific and Industrial Research. Bulletin No. 6.) Paper, 50 pp., plates, 6s. 8½d.

Reports the results of an extensive laboratory investigation of the structure of electrodeposited iron, together with the author's conclusions regarding the influence of various factors upon this structure. The effects of temperature, current density, and movement of the cathode or electrolyte are given special attention. The conclusion is reached that the general theories entertained in regard to the crystallization of other substances hold also for deposited metal and that the dominant factor governing structure is concentration.

PULLING TOGETHER. By John T. Broderick. Robson & Adee, Schenectady, 1922. Cloth, 5×8 in., 141 pp., $1.

A discussion of current problems connected with the relations of capital and labor, with employee representation as the central theme. Dr. Steinmetz has contributed a brief introduction.

SYNTHETIC-GASOLINE PRODUCTION

(Continued from page 595)

B. = gravity of crude oil in degrees Baumé
n = percentage of natural gasoline of 58 deg. B. gravity in the crude
c = value of crude oil at refinery in dollars per bbl.
f = value of fuel oil at refinery in dollars per bbl.
s = value of gas oil at refinery in dollars per bbl.
a = percentage of artificial or synthetic gasoline in crude.

(1) Percentage of artificial gasoline obtainable by commercial cracking:

$$a = \frac{[100 - n]\,[35 + 1.45\,(\text{B.} - 10 - 0.3n)]}{100}$$

Total gasoline = $n + a$

(2) Cost (C_1) of gasoline per gallon when made by skimming only:

$$C_1 = \frac{c + 0.35 - f\,(0.95 - 0.01\,n)}{0.42\,n}$$

(3) Cost (C_2) of gasoline per gallon when made by cracking and skimming:

$$C_2 = \frac{c + 0.40 + a\,(0.0202 + 0.015\,f) - f\,(0.95 - 0.01\,n)}{0.42\,(a + n)}$$

(4) Cost (C_3) of gasoline per gallon when made by cracking gas oil:

$$C_3 = \frac{\$2.02 + 1.41\,s - 0.05\,f}{42}$$

ILLUSTRATIONS OF PRECEDING FORMULAS

(1) Total gasoline from crude oils:

	Sp. Gr., deg. B.	Per Cent Natural	Per Cent Artificial	Per Cent Total
Mexia, Texas crude	37	5	68	73
Burkburnett, Texas	40	40	37	77
Ranger, Texas	38	25	49	74
Panuco, Mexico	12	5	34	39
Tuxpan, Mexico	17.5	15	32	47

(2) Cost (C_1) of gasoline by skimming only (c = $2.00 per bbl.; n = 25 per cent; B. = 37 deg.; f = $1.00 per bbl.):

$$C_1 = \frac{2.35 - 1\,(0.95 - 0.25)}{(0.42)\,(25)} = 15.7 \text{ cents per gal.}$$

(3) Cost (C_2) of gasoline by skimming and cracking, using values given in (2):

$$C_2 = \frac{2.00 + 0.40 + 47.4\,(0.0202 + 0.015) - (0.95 - 0.25)}{0.42\,(47.4 + 25.0)} = 11 \text{ cents per gal.}$$

(4) Cost (C_3) of gasoline made from gas oil with s = $1.25 and f = $1.00:

$$C_3 = \frac{\$2.02 + 1.75 - 0.05}{42} = 8.9 \text{ cents per gal.}$$

ACID-RESISTING METALS AND ALLOYS

(Continued from page 580)

of acid or combinations of acids other than sulphuric, namely, nitric, hydrochloric, hydrofluoric, acetic, stearic, oleic, etc., and outside of those with nitric acid, have been fairly successful. Most of the tests have been conducted with acids and solutions at normal temperature. When subjected to the higher temperatures the losses are much greater, and this makes the solution of the problem even more complex.

There are few known metals or alloys that will resist the action of nitric acid or a combination of nitric with other acids, and the general use of these few is either prohibited by their rareness and cost, or by the fact that they cannot be produced in such a way as to make them at all interesting from a commercial standpoint so far as mine pumps and accessories, apparatus for the chemical industries, etc., are concerned.

Metals and alloys which are required to be highly resistant to the effects of corrosion and erosion, and at the same time commercially practicable, must be of such a nature that they can be easily cast, rolled, drawn, and machined, so that all parts of a pump or other apparatus can be readily made from them, including piping, valves, etc., otherwise the field covered by such metals must be more or less confined and limited.

THE ENGINEERING INDEX

(Registered United States, Great Britain and Canada.)

THE ENGINEERING INDEX presents each month, in conveniently classified form, items descriptive of the articles appearing in the current issues of the world's engineering and scientific press of particular interest to mechanical engineers. At the end of the year the monthly installments are combined along with items dealing with civil, electrical, mining and other branches of engineering, and published in book form, this annual volume having regularly appeared since 1906. In the preparation of the Index by the engineering staff of The American Society of Mechanical Engineers some 1200 technical publications received by the Engineering Societies Library (New York) are regularly reviewed, thus bringing the great resources of that library to the entire engineering profession.

Photoprint copies (white printing on a black background) of any of the articles listed in the Index may be obtained at a price of 25 cents a page. When ordering photoprints identify the article by quoting from the Index item: (1) Title of article; (2) Name of periodical in which it appeared; (3) Volume, number, and date of publication of periodical; (4) Page numbers. A remittance of 25 cents a page should accompany the order. Orders should be sent to the Engineering Societies Library, 29 West 39th Street, New York.

ACCOUNTING

Construction Projects. Accounting for Construction Projects, W. Paxton Little. Elec. World, vol. 79, no. 24, June 17, 1922, pp. 1211–1215, 18 figs. Commission regulation requirements give importance to proper accounting; actual unit-cost information needed as guide to engineers and executives; outline of specific methods that have been found successful.

AERONAUTICAL INSTRUMENTS

Air Service Tests. Air Service Tests New Instruments, S. R. Winters. Aviation, vol. 12, no. 26, June 26, 1922, pp. 755–756, 3 figs. Rate of climb indicator, bubble statoscopes and new barograph tested in balloon flights.

Sylphon Diaphragms. Sylphon Diaphragms, H. N. Eaton and G. H. Keulegan. Aerial Age, vol. 15, no. 15, June 26, 1922, pp. 370–372, 4 figs. Method for predicting their performance for purposes of instrument design.

AERONAUTICS

Government Laboratories, Aid. Government Laboratories Aid Aircraft Growth, P. M. Heldt. Automotive Industries, vol. 46, no. 26, June 29, 1922, pp. 1423–1426, 3 figs. Aeronautic session of S. A. E. develops discussion on aircraft performance formulas, government subsidies, and commercial flying. McCook field work is shown in motion pictures.

Standard Atmosphere. Standard Atmosphere, Willis Ray Gregg. Nat. Advisory Committee for Aeronautics Report no. 147, June 1922, 4 figs. Use of Toussaint's formula in determining standard atmosphere up to 33,000 ft. and tables showing values. Based in part on paper entitled An Aerological Survey of the U. S. to be published by Weather Bureau.

AIR COMPRESSORS

Centrifugal. A New Air Compressor (Ein Neuer Luftkompressor). E. Löwenstein. Deutsche Optische Wochenschrift, vol. 8, no. 22, May 28, 1922, pp. 413–414, 4 figs. Describes new compressor by Götz, having very high efficiency and requiring little power, for use in glass-blowing and technical glass industries.

AIRCRAFT

Research in America. America Makes Creditable Showing in Aircraft Research, Archibald Black. Automotive Industries, vol. 46, no. 23, June 8, 1922, pp. 1257–1265, 13 figs. Speed and reliability increased; helicopters; variable-pitch propeller; landing-field development; Handley Page slotted wing.

AIRPLANE ENGINES

Developing, Method of. A Method of Developing Aircraft Engines, Geo. E. A. Hallett. Soc. Automotive Engrs. Jl., vol. 10, no. 6, June 1922, pp. 457–462, 10 figs. Outline of procedure taken by Air Service before beginning actual design, and subsequent developments.

German, Siemens-Halske. A New German Aeronautical Engine, Erik Hildesheim. Aviation, vol. 12, no. 24, June 12, 1922, p. 693, 3 figs. Siemens-Halske 50–60 hp. air-cooled radial engine; first example of German post-war commercial design.

German 5-Cylinder Radial. A New Low-Power German Radial Air-Cooled Aero Engine. Flight, vol. 14, no. 23, June 8, 1922, pp. 326–327, 3 figs. Description of 60-hp. Siemens-Halske 5-cylinder, 4-stroke engine.

Metals for. Metallurgical Problems of the Airplane Engine (Le Probleme metallurgique pose par le Moteur d'Aviation), C. Grard. Aeronautique, vol. 4, no. 46, May 1922, pp. 156–165. Conditions metals must fulfill for construction of airplane engines.

Silencers. The Silent Airplane and the Silent Engine (L'avion silencieux et la moteur silencieux), Charles Dollfus. Aéronautique, vol. 4, no. 36, May 1922, pp. 145–147, 3 figs. Describes Schneebeli and Birger apparatus for reducing noise.

AIRPLANES

Aerofoils. Flow Tests on Slotted Aerofoils. Flight, vol. 14, no. 22, June 1, 1922, pp. 315–316, 15 figs. Some experiments on behavior of eddies at various points, angles and velocities as shown by means of sal-ammoniac smoke.

BaCo Skylark. The BaCo Skylark. Flight, vol. 14, no. 24, June 15, 1922, pp. 337–339, 5 figs. Description of two-seater tractor biplane fitted with 60-hp. Lawrence air-cooled engine. Constructed by Bethlehem Aircraft Corp.

Propulsion Efficiency vs. Performance. Propulsion Efficiency vs. Performance, Roy G. Miller and F. E. Seiler, Jr. Aviation, vol. 12, no. 25, June 19, 1922, pp. 716–719, 5 figs. Influence of propulsion efficiency on performance of airplanes demonstrated by some well known examples.

Performance Formulas. Airplane Performance Formulas, Edward P. Warner. Soc. Automotive Engrs. Jl., vol. 10, no. 6, June 1922, pp. 469–474, 7 figs. Process of deriving simplified formulas and consideration of elements such as minimum and maximum speeds, climbing ability, etc.

Slotted-Wing Theory. Theory of the Slotted Wing, A. Betz. Nat. Advisory Committee for Aeronautics Technica Notes, no. 100, June 1922, 13 pp., 7 figs. Means of varying coefficient of lift, thereby reducing difficulties of taking off and landing and making greater flight speeds possible; suggestions for theories from which formulas may be developed. From Berichte u. Abhandlungen der Wissenschaftlichen Gesellschaft für Luftfahrt, no. 6, Jan., 1922. See also Aerial Age, vol. 15, no. 15, June 26, 1922, pp. 366–368, 6 figs.

Two-Way. Introducing the Two-Way Airplane, John B. Flowers. Aviation, vol. 13, no. 1, July 3, 1922, pp. 9–10, 1 fig. Tentative design presented to stimulate thought in this direction and criticism of idea, by well-known aeronautical engineer.

AIRSHIPS

Wright Dirigible Engine. The Wright Dirigible Engine and Its Development for the Navy, George J. Mead. Aerial Age, vol. 15, no. 15, June 19, 1922, pp. 342–343. Six-cylinder, vertical, water-cooled engine with 1850 cu. in. displacement, weighing 1320 lb. and developing 400 hp.

ALLOYS

See ALUMINUM ALLOYS, NICKEL ALLOYS, ZINC ALLOYS.

ALUMINUM

Coating With. Coating With Aluminum (Les recouvrements par l'aluminium), Léon Guillet. Révue de Métallurgie, vol. 19, no. 5, May 1922, pp. 296–297. Describes various processes and their successful application.

ALUMINUM ALLOYS

Aluminum-Silicon. Aluminum-Silicon Alloys and Their Industrial Uses (Les alliages aluminium-silicum et leurs emplois industriels), Leon Guillet. Révue de Métallurgie, vol. 19, no. 5, May 1922, pp. 303–310, 15 figs. Reviews development of this type of alloy and discusses new types and their properties.

Aluminum-Zinc. A Study of Alloys of Aluminum and Zinc, D. Hanson and Marie L. V. Gayler. Raw Material, vol. 5, no. 5, June 1922, pp. 174–181, 29 figs. Results of experiments on work along this line; effects of age hardening. Paper read before British Inst. of Metals.

Light. Light Aluminum Alloys, Prof. F. C. Lea. Metal Industry (Lond.), vol. 20, no. 23, June 9, 1922, pp. 533–536, (includes discussions), 2 figs. Effect of various combinations on melting point and characteristics of alloys. From paper read before Inst. of Metals.

Melting and Pouring. Melting and Pouring Aluminum Alloys. Am. Mach., vol. 57, no. 1, July 6, 1922, pp. 1–4. Proper care of furnace; effect of melting and pouring temperatures on castings; how to overcome foundry difficulties.

[See also DURALUMIN.]

AMMONIA

Capacity Table. A Pound of Ammonia, John E. Starr. Refrig. World, vol. 57, no. 6, June 1922, pp. 19–20. Table showing work of a pound of ammonia when heat is received at various temperatures and discharged at various other temperautres.

Chart, Bureau of Standards. The New Bureau of Standards Ammonia Chart. Ice & Refrigeration, vol. 62, no. 6, June 1922, pp. 461–464, 2 figs. Historical facts; nature of chart, properties of anhydrous ammonia which are represented; characteristic curves to show properties; phases of cycles of operation; some common cycles of operation shown graphically.

ASHES

Use for Refiring. Ash Treatment (Ashen-Aufbereitung), F. A. Gruessner. Technische Blatter, vol. 12, nos. 8 and 9, Feb. 25 and Mar. 4, 1922, pp. 81–82 and 89–90, 3 figs. Feb. 25: Discusses processes of preparing ashes for refiring, such as magnetic separation. Mar. 4: Detailed discussion of magnetic separation.

Washing for Refiring. Utilization of Ashes (Aufbereitung von Feuerungsruckstanden), G. Reder. Archiv für Wärmewirtschaft, vol. 3, no. 5, May 1922, pp. 83–87, 15 figs. Describes number of plants for washing ashes for reuse under boilers.

AUTOMOBILE ENGINES

Air-Cooled. Air-Cooled Engines Subject of Widespread Current Research, J. Edward Schipper. Automotive Industries, vol. 46, no. 23, June 8, 1922, pp. 1214–1218, 7 figs. Producing cooling at hottest points on combustion chamber wall. General Motors copper-cooled car near production.

Citroen, Fuel Economy. Citroen Which Lowered World's Fuel Consumption Record, W. F. Bradley. Automotive Industries, vol. 46, no. 26, June 29, 1922, pp. 1434–1435, 2 figs. New detachable head engine used in fuel trials; total valve head diameter [illegible] in.; reciprocating parts lightened; compression from 65–68 lb.; lubrication follows standard lines; I-section connecting rods; rocker arms mounted on two separate shafts.

Diesel Type. Small Diesel Type Automotive Engine Now in Production. Automotive Industries, vol. 46, no. 24, June 15, 1922, pp. 1320–1321, 2 figs. Four-cylinder Austrian engine designed to avoid excessive compression and combustion pressures, thus

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NOTE.—The abbreviations used in indexing are as follows:

Academy (Acad.)
American (Am.)
Associated (Assoc.)
Association (Assn.)
Bulletin (Bul.)
Bureau (Bur.)
Canadian (Can.)
Chemical or Chemistry (Chem.)
Electrical or Electric (Elec.)
Electrician (Elecn.)
Engineer[s] (Engr.[s])
Engineering (Eng.)
Gazette (Gaz.)
General (Gen.)
Geological (Geol.)
Heating (Heat.)
Industrial (Indus.)
Institute (Inst.)
Institution (Instn.)
International (Int.)
Journal (Jl.)
London (Lond.)
Machinery (Machy.)
Machinist (Mach.)
Magazine (Mag.)
Marine (Mar.)
Materials (Matls.)
Mechanical (Mech.)
Metallurgical (Met.)
Mining (Min.)
Municipal (Mun.)
National (Nat.)
New England (N. E.)
Proceedings (Proc.)
Record (Rec.)
Refrigerating (Refrig.)
Review (Rev.)
Railway (Ry.)
Scientific or Science (Sci.)
Society (Soc.)
State names (Ill., Minn., etc.)
Supplement (Supp.)
Transactions (Trans.)
United States (U. S.)
Ventilating (Vent.)
Western (West.)

reducing strain on working parts. Hindl engine can be started by means of hand crank and operates at speed of 1150 r. p. m.

Economy and Flexibility Aims. Better Economy and Flexibility Are Chief Aims of Engine Development, Herbert Chase. Automotive Industries, vol. 46, no. 23, June 8, 1922, pp. 1266–1269, 4 figs. Research and development work tending towards 40 miles per gal.; lower speed and higher torque; non-throttling engines.

Lubrication. Oil-Pumping, Geo. A. Round. Soc. Automotive Engrs. Jl., vol. 10, no. 6, June 1922, pp. 509–512, 4 figs. Factors controlling rate of oil consumption; methods of lubrication, including splash and force-feed systems; oil-pumping troubles.

Oil Consumption. Oil Consumption, A. A. Bull. Soc. Automotive Engrs. Jl., vol. 10, no. 6, June 1922, pp. 513–522, 19 figs. Fundamental factors affecting oil consumption. Methods of testing.

Overhead Camshaft. Overhead Camshaft Passenger-Car Engines, P. M. Heldt. Soc. Automotive Engrs., vol. 10, no. 6, June 1922, pp. 489–498, 19 figs. Adoption of overhead valves in automobile engines; their use on American cars greatly increased.

Pistons, Light-Metal. Light-Metal Pistons for Automobile Engines. Engineering, vol. 113, no. 2945, June 9, 1922, pp. 716–718, 5 figs. Competitive tests under auspices of German Transport Ministry and Verein Deutscher—Motorfahrzeng-Industrieller by Prof. Gabriel Becker.

AUTOMOBILE FUELS

Alcohol. Alcohol Motor Fuel Research. Petroleum Times, vol. 7, no. 176, May 20, 1922, pp. 711–712. Report of four series of tests which showed that all speeds, both with high and low compression, thermal efficiency obtained with alcohol was higher than that obtainable with petrol or benzol at any compression which could be employed with them.

Detonation of, Blended. Detonation Characteristics of Some Blended Motor-Fuels, Thomas Midgley, Jr. and T. A. Boyd. Soc. Automotive Engrs. Jl., vol. 10, no. 6, June 1922, pp. 451–456, 5 figs. Effects of admixtures of various percentages of alcohol and alcohol-benzine for reducing detonating tendency of paraffin hydrocarbons.

Low-Volatile. Can Less Volatile Motor Fuels Be Used Successfully? F. C. Mock and M. E. Chandler. Automotive Industries, vol. 46, no. 25, June 22, 1922, pp. 1372–1376, 8 figs. Proper fuel preparation prior to combustion involves formation of continuously homogeneous mixture without liquid film or drops at lowest possible temperature. Advantages and disadvantages of present methods of heat application. Condensed from paper read before Soc. Automotive Engrs.

Research, Effect on Industry. Automotive Engineering Development Rests Largely on Fuel Research, Herbert Chase. Automotive Industries, vol. 46, no. 23, June 8, 1922, pp. 1219–1231, 16 figs. Gasoline substitutes used in other countries; cracking processes developed; work of Ricardo and Kettering.

AUTOMOBILE INDUSTRY

André Citroen Plant, France. The André Citroen Establishments. Engineering, vol. 113, no. 2945 June 9, 1922, pp. 705–708, 5 figs. Description of plant where sixty 10-hp. automobiles are turned out daily. Some details of buildings which cover 20 acres.

British Research, Economy. British Automotive Research Devoted to Securing Operating Economy, M. W. Bourdon. Automotive Industries, vol. 46, no. 24, June 15, 1922, pp. 1322–1324. Use of combined oil and air cooling for engines being studied in several quarters. Experiments proceeding to further use of light alloys in chassis construction. Reducing bus operating costs.

Canadian Plant at Ford, Ont. Producing 55,000 Cars and Trucks a Year. Can. Machy., vol. 27, no. 25, June 22, 1922, pp. 26–31, 11 figs. Outstanding features of Ford Motor Co. of Canada at Ford, Ontario.

General Motors Plant, Chicago. Making Five Types of Cars At One Plant. Can. Machy., vol. 27, no. 25, June 22, 1922, pp. 35–37, 6 figs. Outstanding features of plant where two types of Chevrolet, McLaughlin-Buick, Oldsmobile and Oakland are turned out for Canadian consumption.

Research in Iron and Steel. Better Cars and Trucks May Result from Iron and Steel Research, P. M. Heldt. Automotive Industries, vol. 46, no. 23, June 8, 1922, p. 1270. Study of chrome-molybdenum steel, high-carbon steel brake drums, resistance-to-wear investigation and heat treatment.

Research in Light Metals. Light Metal Research Will Affect Future Car and Truck Design. Automotive Industries, vol. 46, no. 23, June 8, 1922, pp. 1278–1279. New all-aluminum car. Rosenhain's aluminum alloy for pistons. Germans light alloys in high-speed engines. Aluminum forging and soldering.

Research in Non-Ferrous Metals. Non-Ferrous Metal Research Affects Design of Small Automotive Parts. Automotive Industries, vol. 46, no. 23, June 8, 1922, pp. 1289–1290. New coefficient of expansion determined for nickel; properties of monel metal; brazing flux.

S.A.E. Standard Report. New S.A.E. Standard Report of Interest to Many Manufacturers. Automotive Industries, vol. 46, no. 24, June 15, 1922, pp. 1328–1336, 10 figs. Recommendations covering bumper mountings, oil-drain plugs, spring steel, truck-axle parts, electrical equipment, tractor drawbar adjustment, bronze and aluminum sheet, bearing metals, ball studs, screw threads and serrated fittings are important to vehicle as well as to parts makers.

AUTOMOBILES

Differentials, With and Without. With and Without the Differential, G. E. Bradshaw. Autocar, vol. 48, no. 1382, April 15, 1922, pp. 611–613. Upholding argument that differentialless axle is not suitable for touring cars.

Suspension. New System of Spring-Suspension for Automotive Vehicles, H. M. Crane. Soc. Automotive Engrs. Jl., vol. 10, no. 6, June 1922, pp. 463–465, 2 figs. History; Hotchkiss drive for shaft-driven cars, rear-axle mountings and device developed by author.

Taxicabs, European. New European Taxicabs Are Designed for High Economy, W. F. Bradley. Automotive Industries, vol. 46, no. 24, June 15, 1922, pp. 1316–1319, 3 figs. Citroen with small four-cylinder engine, 111-in. wheelbase and 46-in. track, and body seating only two passengers has proved highly successful: 3200 Renault cabs with larger engine, same wheelbase, 56-in. track, and four-passenger body are now competing.

Transmission, Mechanical Shift. Gear Transmission with a Mechanical Shift, H. O. Herzog. Am. Mach., vol. 57, no. 1, July 6, 1922, p. 17, 5 figs. on p. 16. Describes Saden gear shift, a German device; 4 speeds and reverse; operator merely selects speed desired, shift is mechanical.

Trojan Two-Stroke. The 10 Hp. Two-Stroke Trojan. Autocar, vol. 48, no. 1392, June 24, 1922, pp. 1071–1073, 9 figs. Small utility car incorporating novel two-stroke engine, epicyclic gear, and solid tires.

Waverley. The New 10–15 Hp. Waverley Car. Auto, vol. 27, no. 23, June 8, 1922, pp. 467–470, 12 figs. New and lighter model of well known London-made car with Coventry-Simplex, four-cylinder monobloc engine.

Webb Light Car. The Webb Light Car. Auto, vol. 27, no. 24, June 15, 1922, pp. 489–491, 11 figs. Description of British car of pleasing design, four-cylinder Alpha engine of 1,088 cc. piston displacement.

AVIATION

Traffic Law Proposed. Proposed Air Traffic Law, Geo. Ripert. Aerial Age, vol. 15, no. 14, June 12, 1922, pp. 320–323. Suggestions for international laws deduced from those adopted at international conventions and by various governments.

B

BEAMS

Plate. Dimensions of Plate Beams (Dimensionierung Einfach Bewehrter Plattenbalken), Leo Bäron. Bauingenieur, vol. 3, no. 9, May 15, 1922, pp. 273–275. Gives new, simplified, expeditious and reliable method of calculation, and explains it by practical examples.

BEARING METALS

Babbitt. The Microstructure of Babbitt Metal, A. McArthur Johnston and R. W. Irwin. So. African Instn. of Engrs. Jl., vol. 20, no. 10, May 1922, pp. 197–211, 21 figs. Characteristics, construction, and properties of alloys recommended by Chamber of Mines Eng. Standardization Committee; nature of microstructure o feach alloy and physical properties likely to be found.

White-Metal and Red-Brass. White Metal and Red Brass Bearing Metals for Machines, Bushings, Collars, Etc. (Weissguss- und Rotguss-Lagermetalle für Maschinen, Lagerfutter, Zapfenlager usw), Zeit. für die Gesamte Giessereipraxis, vol. 43, no. 23, June 10, 1922, pp. 316–317. Composition of bearing metals, especially for machine tools; gives tables of percentages of tin, zinc, antimony, copper, lead, etc., also of their mechanical properties, elasticity, tensile strength, elongation, hardness, construction.

BEARINGS

Babbitted, Troubles. Fourteen Causes of Trouble With Babbitted Bearings, L. D. Allen. Belting, vol. 20, no. 6, June 1922, pp. 55–56, 1 fig. Points that should be investigated when bearings give trouble.

Motor. Some Pointers on Bearings, A. L. Gear. Elec. Rev. & Indus. Engr., vol. 80, no. 6, June 1922, pp. 265–270, 309–310, 13 figs. Sleeve-bearing materials, design and construction.

Steam-Engine, Lubrication of. The Problem of Lubricating Steam-Engine Bearings, W. F. Osborne. Power, vol. 56, no. 2, July 11, 1922, pp. 53–54, 1 fig. Method of lubrication; effect of characteristics of engine on selection of suitable lubrication.

BEARINGS, BALL

Advantages. On the Quality of Various Bearings and the Advantages of Ball Bearings (Note sur les qualités générales des divers paliers de transmissions, avantages des paliers à billes), H. Bursie. Révue Générale de l'Electricité, vol. 11, no. 21, May 27, 1922, pp. 792–794, 3 figs. Progress made in recent years in journal bearings and SKF ball bearings.

BELT DRIVE

Power Transmission by. Power Transmission by Belting. Machy. (Lond), vol. 20, no. 507, June 15, 1922, pp. 325–327, 4 figs. Characteristics of leather belting and charts for simplifying calculations.

Power Transmitted. How Much Power is Belt Transmitting? W. F. Schaphorst. Nat. Engr., vol. 26, no. 6, June 1922, pp. 268–269, 1 fig. Simple method of determining from easily obtained instruments.

BELTING

Cellulose. Experiments With Cellulose Belting (Versuche mit Zellstofftreibriemen), M. Rudeloff. Zeit. des Vereines deutscher Ingenieure, vol. 66, nos. 19 and 20, May 13 and 20, 1922, pp. 466–469 and 491–494, 23 figs. May 13: Equipment for experiment, details of testing operation and conditions under which each test was carried out. May 20: Discusses friction in ball bearings in pulley-driven machinery; determination of useful work; records of revolution counters.

Grain Elevators. Belting Systems in Two Large Grain Elevators, D. R. Egbert. Belting, vol. 20, no. 6, June 1922, pp. 13–17, 6 figs. Reconstructed C. & N. W. elevator contains 8½ miles of conveyor and elevator belt; New Orléans public elevator; four installations compared.

Slide Rule, Calculation by. The Improved Belt Slide Rule, Carl G. Barth. Management Eng., vol. 2, no. 6, June 1922, pp. 351–354, 2 figs. As now constructed it solves problems for three classes of belts, viz., machine, heavy countershaft, and light countershaft.

BLAST FURNACES

China. New Steel Plant is Wholly Chinese. Trans-Pacific, vol. 6, no. 4, April 1922, pp. 72–74, 1 fig. Some details of 250-ton blast furnace of Lungyen Min. Administration near Peking which is expected to make iron this spring.

Fuel Economy. The Alabama Company's No. 1 Stack Breaks Production Record on Low Fuel Consumption, H. R. Stuyvesant. Blast Furnace & Steel Plant, vol. 10, no. 6, June 1, 1922, pp. 343–346, 1 fig. Production increased 17 per cent, coke consumption decreased 30 per cent; labor force reduced 50 per cent.

BOILER FEEDWATER

Feeding Compound with. Methods of Feeding Boiler Compound With the Feed Water, W. H. Wakeman. Southern Engr., vol. 37, no. 4, June 1922, pp. 43–45, 4 figs. Description of successful application.

BOILER FIRING

Half-Gas. Improvements in Half-Gas Firing (Neuerungen an Halbgas-Feuerungen), Graafen. Braunkohle, vol. 21, no. 6, May 13, 1922, pp. 113–120 and (discussion) 120–124, 18 figs. Describes Völcker, Peretti, Bergman, and other types of firing systems.

BOILER PLATES

Strength and Elasticity. Strength and Elasticity of Boiler Plate at Elevated Temperatures, H. J. French. Chem. & Met. Eng., vol. 26, no. 26, June 28, 1922, pp. 1207–1209, 3 figs. Proportional limit maintained or increased with first temperature rise; tensile strength has slight maximum at about 250 deg. cent., but both fall off badly at higher temperatures; reduction and elongation have minimum at about 260 deg. cent., but recover their original value around 450 deg. cent.

BOILER TUBES

Safe Ends, Electric Welding. Electrically Safe Ending Boiler Tubes, J. J. Sullivan. Boiler Maker, vol. 22, no. 6, June 1922, pp. 153–154, 2 figs. Summary of results in safe ending boiler tubes and flues with Thomson electric butt welder at Nashville, Chattanooga & St. Louis Ry., Nashville, Tenn.

BOILERS

Electrically Heated. Production of Steam and Hot Water in the Electric Boiler (Dampf- und Warmwassererzeugung in elektrischen Dampfkesseln), Hindelang. Zeit. des Bayer. Revisions-Vereins, vol. 26, no. 10, May 31, 1922, pp. 84–85, 1 fig. Providing hot water to Municipal Bath and German Museum in Munich.

Fire Bridges. Arches in Central Heating Boilers (Schamotte-Einbauten in Zentralheizungs-Kesseln) de Grahl. Glasers Annalen, vol. 90, no. 12, June 15, 1922, pp. 215–221, 5 figs. Nassel fire bridge and tests made to establish its efficiency, including flue-gas analysis, determination of heat losses, etc.

Ladd-Belleville. Large Units of Modern Boiler Plants (Les grandes unités des chaufferies modernes), C. Radiguer. Révue Générale de l'Électricité, vol. 11, no. 24, June 17, 1922, pp. 897–906, 6 figs. Describes Ladd-Belleville boilers at Ford plant on River Rouge, their operation, upkeep, firing with gas and pulverized coal, etc.

[See also LOCOMOTIVE BOILERS.]

BOILERS, WATER-TUBE

Spearing, Manufacture of. The Manufacture of the Spearing Boiler. Eng. Rev., vol. 35, no. 11, May 1922, pp. 379–381, 3 figs. Facts about design, manufacture and testing of this comparatively new type.

BRASS

Forgings. Brass Forgings, C. G. Heiby. Metal Industry (N. Y.), vol. 20, no. 6, June 1922, pp. 220–221. How produced; chilled cast blanks; composition of metal; microstructure of forgings. Paper read at Convention of A.F.A.

The Development of Brass Forging, Oscar T. Roder. Forging & Heat Treating, vol. 8, no. 6, June 1922, pp. 256–259, 7 figs. Art of working brass while hot; general details of process of presses used and of die construction; composition; physical properties; microstructure of forgings and castings.

BRAZING

Dip Brazing and Heat Treatment. Dip-Brazing With 80:20 Brass and the Heat Treatment of Brazed Joints, E. V. Schaal. Chem. & Met. Eng., vol. 26, no. 24, June 14, 1922, pp. 1121–1125, 9 figs. Satis-

factory methods for dip brazing; strengths of joint and effect of heat-treatment; metallography of brazed joints; strength of bond between brass and steel.

BUSES

Trolley, Overhead Materials for. Overhead Materials and Current Collection Equipment for Trolley Bus Lines, M. W. Manz. Bus Transportation, vol. 1, no. 6, June 1922, pp. 327–330, 12 figs. Advantages of continuing use of present standards as far as practicable. Details of trolley harp, base and overhead special work design.

C

CABLEWAYS

Aerial. The Use of Electric Telphers for Conveying, in Dock Operations (Die Verwendung der Elektrohängebahn im Hafenbetrieb), Martin Bruckmann. Schiffbau, vol. 23, no. 37, June 14, 1922, pp. 1086–1092, 16 figs. Mechanical conveying by means of aerial cables, electric telphers, and cable cranes, and their operation in loading and unloading ships.

CANS

Seaming, Special Machines for. Building Special Machines for Can-Seaming, Arthur Mumper. Machy. (N. Y.), vol. 28, no. 11, July 1922, pp. 899–902, 3 figs. Highly developed type of single-purpose machine which closes ends of cylindrical tin containers.

CAR CONSTRUCTION

Side Frame. A One Piece Wrought Steel Truck Side Frame. Ry. Rev., vol. 70, no. 24, June 17, 1922, pp. 918–920, 6 figs. Symington type which is sheared and formed under hydraulic press; electric welded in final form.

CAR LIGHTING

Generator, Direct-Drive. Direct Driving Axle Generators for Passenger Cars. Ry. Rev., vol. 70, no. 25, June 24, 1922, pp. 972–974, 5 figs. Am. Ry. Assn. committee on train lighting and equipment report direct drive still in development stage. (Abstract.)

Generator, Body Suspension. Long Island Changes Generator Suspensions. Ry. Elec. Engr., vol. 13, no. 6, June 1922, pp. 190–192, 2 figs. Truck mounted machines placed on car bodies show economy by giving greater belt mileage.

CARS

Dump. Car Tippers and Automatic Unloading Cars (Wagenkipper und Selbstentladewagen), Wintermeyer. Verkehrstechnik, vol. 39, no. 23, June 9, 1922, pp. 317–320, 10 figs. Principles of construction of cars for coal, coal, ore, sand and similar material; automatic unloading to keep cars in circulation.

CARS, COAL

N. & W. Ry., 120-Ton. Coal Car of 120-Tons Capacity—Norfolk and Western Railway. Ry. & Locomotive Eng., vol. 35, no. 6, June 1922, pp. 142–145, 7 figs. Details of construction and design.

CASE-HARDENING

Distortion. Distortion Produced in Casehardening, A. A. Blue. Am. Mach., vol. 56, no. 25, June 22, 1922, pp. 915–916, 3 figs. Consistent minimum warpage in manganese steel; large holes decrease, small holes increase when carbonized; greater wall thickness produces greater effect.

Steel, Failures. Causes of Failures in Case-Hardening Steel. Iron Age, vol. 109, no. 26, June 29, 1922, pp. 1807–1808. Non-metallic impurities, chiefly dissolved oxides, responsible in many cases in which hardening process has been thought at fault.

Selective. Selective Case-Carburizing, W. P. Wood and O. W. McMullan. Chem. & Met. Eng., vol. 26, no. 23, June 7, 1922, pp. 1077–1080, 4 figs. Review of various methods of producing local cases; in general, electrodeposited copper has furnished best protection; non-metallic coating whose application and removal presents no great difficulties is described.

CAST IRON

American vs. British. American Versus British Grey Cast Iron, F. J. Cook. Can. Foundryman, vol. 13, no. 6, June 1922, pp. 26–32, 7 figs. Superior qualities of British iron shown; sulphur and phosphorus not as detrimental as generally believed; soft castings depreciate value of American machinery.

CASTINGS

Centrifugal. Centrifugal Castings, N. Lilienberg. Blast Furnace & Steel Plant, vol. 10, no. 7, July 1922, pp. 375–379, 9 figs. States advantages of making centrifugal castings in vertical molds rather than in horizontal molds as is customary; theoretical calculations necessary for method are given.

Cutting and Welding. Cutting and Welding of Castings, G. O. Carter. Iron Trade Rev., vol. 71, no. 2, July 13, 1922, pp. 107–110. Minimum interruption caused by changing of tips, altering of pressures, etc.; castings should be segregated according to size of risers. Paper read before Am. Foundrymen's Convention.

Feeding Heads, Without. The Making of Castings Without Feeding Heads, E. Ronceray. Foundry Trade Jl., vol. 25, no. 302, June 1, 1922, pp. 393–397. Suggestions of importance in practice which would obviate necessity for heads in many cases. Paper read before Inst. British Foundrymen.

Plaster Molds for. Plaster Molds for Small Castings. Machy. (Lond.), vol. 20, no. 509, June 29, 1922, pp. 398–399, 2 figs. Advantageous features for models and exacting commercial work.

CEMENT MANUFACTURE

Fusion Process. Possibilities of Fusion Process for Cement Production, S. L. Meyers. Concrete, vol. 20, no. 6, June 1922, pp. 105–107, 5 figs. This process contains fuel economy possibilities that rotary kiln with sintering methods does not.

CEMENT MILLS

Iowa. Building and Operating Iowa's First Cement Plant, W. T. Christine. Cement, Mill & Quarry, vol. 20, no. 10, May 20, 1922, pp. 25–34, 19 figs. Plant was put into operation in 1908; intricate process of cement manufacture; waste-heat boiler furnishes all power to operate plant.

CEMENT, PORTLAND

Chemical Analysis. Interpreting the Chemical Analysis of Portland Cement, J. C. Witt. Cement & Eng. News, vol. 34, no. 6, June 1922, pp. 21–23. Suggested system of recasting has not demonstrated relationship of results with physical behavior.

CENTRAL STATIONS

Superpower. The Superpower Undertaking in Styria (Austria) (Das steirische Grosskraftwerksunternehmen), Richard Hofbauer. Elektrotechnik u. Maschinenbau, vol. 40, no. 23, June 4, 1922, pp. 265–269. Discusses power works of Enns group, Mur groupe, water storage works at Teigitsch and Mixnitz, and districts they supply with power.

CLUTCHES

Magnetic. Magnetic Clutches in the Cement Industry, W. H. Costello. Cement, Mill & Quarry, vol. 20, no. 11, June 5, 1922, pp. 23–24. Transmits from 600 to 800 hp. Torque requirements; starting tube mill; shaft alignment.

COAL

Briquetting. Briquetting of Peat (Brikettierung von Rohtorf oder Kohlenschlamm durch maschinelle Druckentwässerung ohne Bindemittel), Kampers. Technische Blätter, vol. 12, no. 5, Feb. 4, 1922, pp. 49–51, 4 figs. Processes depending on extracting water by pressure.

Production Costs. Analyzing the Cost of Producing Anthracite, S. D. Warriner. Min. & Metallurgy, no. 187, July 1922, pp. 7–9. Explanation of wide difference in price to consumer from labor cost in mine.

Steaming. Coal Steaming, A. W. Binns. Power Plant Eng., vol. 26, no. 12, June 15, 1922, pp. 595–598, 8 figs. Costs, steam consumption and mechanical details.

COAL HANDLING

Equipment for Ash and. On Coal and Ash Handling Equipment, Harry R. Westcott. Power House, vol. 15, no. 10, May 20, 1922, pp. 25–29 and 42. Numerous types of apparatus for these purposes are described in outline, and suitability of one or other is indicated under differing conditions.

COKE

Non-Coking Coals. Coke from "Non-Coking" Coals. Iron & Coal Trades Rev., vol. 104, no. 2828, May 12, 1922, pp. 708–709. Process of heating non-coking coals so rapidly that resinous content is decomposed before excessive oxidation occurs.

COMPRESSED AIR

Interfactory Mail Despatch. Development of Flat Postal Tubes for Conveying Sheets of Paper to Distant Departments (Die Entwicklung der Flachrohrpost für die Beförderung von Zetteln in Fernämtern), Carl Beckmann. Ziet. für Fernmeldetchnik Werk- und Gerätebau, vol. 3, no. 5, May 16, 1922, pp. 77–82, 21 figs. System of pneumatic conveying which does without condensers, documents being conveyed direct by air to distant parts of factory.

COMPRESSORS

See AIR COMPRESSORS.

CONCRETE

Alkali Action. The Effect of Alkali Upon Concrete, S. H. McCroy. Cement & Eng. News, vol. 34, no. 6, June 1922, pp. 17–18. Decomposition caused and explanations of it offered. No method known of preventing such deterioration, but impermeability retards it. Recommendations as to aggregate, proportioning and placing of concrete.

Lumber. Concrete Lumber Industry Is Growing, W. A. Scott. Concrete Products, vol. 22, no. 6, June 1922, pp. 29–31, 8 figs. Company in California has developed system of manufacture which is leased in assigned territory.

CONCRETE CONSTRUCTION, REINFORCED

Calculation. Reinforced-Concrete Construction Work and Calculations (Rechnung und Konstruktion im Eisenbetonbau), Robert Otzen. Bauingenieur, vol. 3, no. 9, May 15, 1922, pp. 262–266, 1 fig. Methods of calculating cross-sections, stresses, etc., develops formulas and gives examples of application.

CONDENSERS, STEAM

Air Pumps for. The C. M. and M.-Delas Air Extractor. Electrician, vol. 88, no. 2300, June 16, 1922, pp. 718–719, 3 figs. Results of tests made in Paris workshops of Société Condenseurs Délas.

Tube Packing. Condenser Tube Packing. Am. Mar. Engr., vol. 17, no. 6, June 1922, pp. 25–31, 17 figs. Underlying causes of corrosion and an easy economical solution of problem.

COOLERS

Live-Steam. Live-Steam Coolers (Heissdampf-Kühlapparate). Archiv für Wärmewirtschaft, vol. 3, no. 5, May 1922, pp. 91–92, 4 figs. Describes cooler built by Sieffert & Co., A. G., for cooling live steam to be used in manufacturing where waste-steam supply is insufficient.

CORES

Machines for Manufacture of. Production of Cores by Means of Machines (Die Herstellung von Kernen mettels Maschinen), Georg Hoffmann. Giesserei-Zeitung, vol. 19, nos. 13 and 15, Mar. 28, and Apr. 11, 1922, pp. 199–203 and 241–245, 33 figs. Mar. 28: Detailed description of American and hydraulic core machines. Apr. 11: Describes large and small types of core-making machines.

CORROSION

Iron and Steel. Corrosion of Iron and Steel—Influence of Molecular Concentration on Immersion-Test Investigations, D. M. Strickland. Chem. & Met. Eng., vol. 26, no. 25, June 21, 1922, pp. 1165–1169, 1 fig. Initial rate of corrosion most important, since solution rates change as equilibrium approaches; spent solutions often harmless, but sometimes accelerate corrosion; short tests in circulating pure chemicals logical method for comparative tests.

COST ACCOUNTING

Concrete Products Industry. Cost Accounting in Products Manufacture, Mac Hanson. Concrete, vol. 20, no. 6, June 1922, pp. 235–238, 3 figs. Relation of management to profits; valuable system which is being used and requires only few hours per week for usual product plant.

COTTON

English and American Practice. Cotton Manufacture, Sidney B. Paine. Engrs. & Eng., May 1922, pp. 149–153 and (discussion) 153–154. Conditions under which English textile industry has been developed; difference between English and American practice; suggestions toward adoption of English details which have proved profitable.

CRANES

Hammerhead, 200-Ton. Two-Hundred-Ton Fitting Out Crane at Camden Yard. Mar. Eng., vol. 27, no. 6, June 1922, pp. 383–385, 4 figs. Details of construction and operation of huge electrically operated hammerhead crane installed at South Yard of N. Y. Shipbldg. Corp.

CUPOLAS

Charging Machines. Charging Machines for Cupolas. Engr., vol. 133, no. 3470, June 30, 1922, pp. 727–728, 5 figs. Design of Thwaites Bros., Ltd., Bradford, which combines comparative low first cost and ease of installation.

Operation. Cupola Furnace Operations, Requirements in Coke and Its Influence in Enriching the Melt in Sulphur (Der hochentwickelte Kupolofenbetrieb, sein Koksbedarf und sein Einfluss auf die Schwefelanreicherung der Schmelze), Hörnig. Giesserei-Zeitung, vol. 19, no. 14, Apr. 4, 1922, pp. 215–220, 6 figs. Discusses modern cupola furnace with air preheater, and its operation.

CUTTING METALS

Cutting Fluids for. Cutting Fluids, Eugene C. Bingham. Am. Mach., vol. 56, no. 26, June 29, 1922, pp. 958–961, 4 figs. Why adhesion is important lubrication factor; relative physical properties found by tests; best oil for each operation and material. (Abstract.) Tech. Paper No. 204, Bur. of Standards.

D

DIESEL ENGINES

Air Supply. Air for Diesel Engine-Installations, W. P. Sillince. Oil Eng. & Finance, vol. 1, nos. 11 and 13, Mar. 25 and Apr. 8, 1922, pp. 370–371 and 439–440. Survey of air for combustion of fuel, for starting and maneuvering engines, for injection of fuel and to operate auxiliaries.

Compressorless. Compressorless Diesel Engines (Kompressorlose Dieselmaschinen). Schiffbau, vol. 23, no. 36, June 7, 1922, pp. 1055–1057, 7 figs. Discusses Trinkler, Haselwander, and other types, which do without compressor for feeding of fuel.

Construction and Operation. Diesel and Semi-Diesel Engines (Moteurs Diesel et Semi-Diesel), Ed. Allar. Bul. des Associations Françaises de Propriétaires d'Apparails a Vapeur, vol. 3, no. 8, Apr. 1922, pp. 86–105, 5 figs. Theory, principle of combustion, construction, operation, and application.

Petroleum as Fuel. Some Characteristics of Petroleum Oils Used On Diesel Engines, Harold Moore. Oil Eng. & Finance, vol. 1, no. 14, Apr. 15, 1922, pp. 458–460 and 463–464. Number of analyses of fuel oils from various sources and their value as means of predicting behavior of new oils of similar characteristics. Paper read before Diesel Engine Users Assn.

Tosi. Internal-Combustion Engines (Les moteurs a combustion interne). Génie Civil, vol. 80, no. 25, June 24, 1922, pp. 561–564, 7 figs. Compares two-stroke and four-stroke Diesel engines, their application for marine purposes, and describes in detail Tosi Diesel four-stroke engine.

DURALUMIN

Gearing, for. Duralumin for Gearing, Robert W. Daniels. Am. Mach., vol. 57, no. 2, July 13, 1922, pp. 62–65. History of duralumin; some properties

that make it desirable for worm and other gearing; its strength and wearing qualities.

DUST

Precipitation, Electrical. Electrical Precipitation of Dust and Its Application in the Purification of Gas (La précipitation électrique des poussières), Saget Bul. de la Société Française des Électriciens, vol. 2, no. 12, Feb. 1922, pp. 83–100, 6 figs. Discusses precipitation in metallurgical, sulphuric-acid, and other plants, and advises its more general adoption.

DYNAMOMETERS

Tractor, Recording Type. The Watson Dynamometer, George W. Watson. Engineering, vol. 113, no. 2948, June 30, 1922, pp. 814–816, 10 figs. Tractive force transmitted by oil pressure in one cylinder to spring-actuated piston in smaller cylinder. Link motion controls stylus recording on paper roll actuated by speed of tractor. Time and furrow depth also recorded.

E

ECONOMIZERS

Value of. The Case for the Economizer, Julius Frith. Engineer, vol. 133, no. 3468, June 16, 1922, pp. 655–656, 3 figs. Rigid application of first principle usually shows coal economy but not always reduction of operating costs and features which influence this result.

EDUCATION, ENGINEERING

Technical Literature, Use of. Instruction of Students in the Use of Technical Literature; an Unexploited Phase of Engineering Education, E. H. McClelland. Eng. & Contracting, vol. 57, no. 25, June 21, 1922, pp. 598–600. Importance of research in present-day manufacture and available literature from which to start.

ELASTICITY

Moduli. The Modulus of Elasticity in Mechanical Construction Work (Le rôle du module d'élasticité dans la construction mécanique), R. de Fleury. Révue de Métallurgie, vol. 19, no. 5, May 1922, pp. 298–302. Its application to malleable iron, aluminum bronzes and other light metals, and construction of Diesel, aeronautical, and automobile engines.

ELECTRIC FURNACES

Design. New Electric Furnaces for Temperatures of 2500 Degrees and Over (Neuartige elektrische Öfen für Temperaturen von 2500° und darüber), E. Löwenstein. Centralblatt fur Mineralogie, Geologie und Paläontologie, no. 9, May 1, 1922, pp. 283–285, 3 figs. Describes furnace built by Göttinger Elektroschaltwerk, in which high temperatures can be reached quickly, temperatures can be accurately regulated, current consumption is small; suitable for metals and minerals, and difficultly fusible earths of all kinds.

Fiat. Development of the Italian Iron Industry by Extensive Use of Electric Power in Smelting Works (Ueber die Entwicklung der italienischen Eisenindustrie durch weitgehende Anwendung elektrischer Energie im Schmelzbetrieb), Dornhecker. Stahl u. Eisen, vol. 42, no. 22, June 1, 1922, pp. 845–848, 3 figs. Discusses electric furnaces in iron foundries, especially Fiat furnace, and works of Fiat Co.

ELECTRIC LAMPS, INCANDESCENT

Dangers. Danger of Touching Unclean Incandescent Bulbs (Gefährdungsmöglichkeiten bei Berührung unsauberer Glühlampen), Stefan Jellinek. Elektrotechnische Zeit., vol. 43, no. 24, June 15, 1922, pp. 815–817, 4 figs. Discusses case of a death resulting from touching glass bulb covered with lime spots. Very considerable potentials were found by making contact with unclean bulbs.

ELECTRIC LOCOMOTIVES

British Design. Electric Locomotives, Vincent L. Raven. Ry. Gaz., vol. 36, no. 25, June 23, 1922, pp. 994–996, 2 figs. Design of shunting, freight and passenger locomotives. Foreign practice in relation to British conditions. Summary of paper read before Instn. Mech. Engr.

Mechanical Parts. Mechanical Parts of Electric Locomotives, H. A. Houston. Ry. Mech. Engr., vol. 96, no. 6, June 1922, pp. 319–322, 12 figs. Comparison with steam locomotives; details of construction of outside-frame type.

ELECTRIC PLANTS

Turbo-Alternator. Some Notes on the Design of Generating Plant, C. F. Hewitt. Elec. Times, vol. 61, no. 1599, June 8, 1922, pp. 552–553. Reliability; working conditions; thermal economy, capital cost, ease of operation and general accessibility are design factors in order of their importance.

ELECTRIC WELDING

Apparatus. Electric Welding Installations (Elektrische Schweissanlagen), Karl Midsch. Metall-Technik, vol. 48, no. 19, May 4, 1922, pp. 205–208, 10 figs. Discusses electric arc, resistance, and spot welding, and explains operations and apparatus.

Development. The History of the Development o Electric Welding, J. M. F. Wilson. Elec. News vol. 31, nos. 7 and 11, Apr. 1 and June 1, 1922, pp. 35–37 and 40–41, 3 figs. Discusses carbon-electrode and metal-electrode systems of welding; selection of electrodes; impurities, etc.

Ship Construction. Electric Welding Applied to Steel Construction With Special Reference to Ships, A. T. Wall. Instn. Mech. Engrs. Prac., no. 2, 1922, pp. 239–288, 19 figs. Review of present application to ship construction and indication of further possibilities in steel structures.

Shipyards, Germany. Electric Arc Welding in the German Shipyard at Hamburg (Die elektrische Lichtbogenschweissung auf der Deutschen Werft, Hamburg), W. Heins. Schiffbau, vol. 23, no. 36, June 7, 1922, pp. 1062–1066, 14 figs. Gives a number of examples of handy application.

ENAMELS

Coating. Microscopic Study of Ground Coat and Cover Coat Enamel Reactions, E. E. Geisinger. Am. Ceramic Soc. Jl., vol. 5, no. 6, June 1922, pp. 322–337, 13 figs. Study showing that susceptibility of enamels to furnace gases is easily classified by cross-section under microscope; examples.

ENERGY

World, Economics of. A Swedish Scientist on the World Energy Economics, Svante Arrhenius. Eng. Progress, vol. 3, no. 6, June 1922, pp. 136–138. Consideration of sources of energy which are still available and how long they are likely to last.

ENGINEERING SCHOOLS

Germany. Illuminating Institute Department of the Baden Technical High School at Carlsruhe (Das Lichttechnische Institut der Badischen Technischen Hochschule in Karlsruhe), J. Teichmuler. Zeit. für Beleuchtungswesen, vol. 28, no. 9–10, May 15–31, 1922, pp. 51–55, 9 figs. Series of articles describing building and equipment, curriculum at high school, photometry, diffusion of light, etc.

ENGINEHOUSES

Equipment. Expediting Enginehouse Work at Hoboken. Ry. Mech. Engr., vol. 96, no. 6, June 1922, pp. 301–304, 8 figs. Modern machine equipment and efficient labor-saving devices show good results at D. L. & W. enginehouse.

EXHAUST STEAM

Superheating for Textile Process Work. Textile Plant Superheats Exhaust Steam for Process Work, Power, vol. 55, no. 25, June 20, 1922, pp. 965–966, 2 figs. Easton Finishing Co's method of drying cloth in tentering machine and heating drying rolls.

EXPLOSIVES

C. P. Toluene. Report on the Manufacture of C. P. Toluene from By-Products Plants and Petroleum Distillates, W. K. Kirby. Alumini Mag. of Colorado School of Mines, vol. 12, no. 2, June 1922, pp. 5–10. Description of toluene and its production by scrubbing coal or water gas and synthetic process by cracking petroleum distillates.

Detonators, Lead Plate Test. The Lead Plate Test as Applied to Commercial Detonators, Bennett Grotta. Chem. & Met. Eng., vol. 26, no. 24, June 14, 1922, pp. 1126–1132, 12 figs. Tests and experiments demonstrating its value in grading commercial detonators according to well-defined standards; efficiency of commercial detonators.

Liquid Air. Use of Liquid Air as an Explosive (Empleo de oxigeno liquido como explosivo), Eduardo Carvajal. Revista Minera, Metalurgica y de Ingenieria, vol. 73, no. 2829, Apr. 24, 1922, pp. 230–233, 3 figs. Making of cartridges; comparative costs; method of operation.

F

FANS

Forced-Draft, Operating Characteristics. Operating Characteristics of Forced-Draft Fans, H. E. Corl. Power, vol. 55, no. 26, June 27, 1922, pp. 1012–1013, 2 figs. Recent developments due to underfeed stokers; new type of fan in which maximum hp. is only approximately 5 per cent higher than rated hp.

Output and Efficiency. The Characteristic Curves of Fans, and Their Application to Pre-determine the Output and Efficiency of Fans Working Singly and In Parallel On Various Resistances, Joseph Parker. Instn. Min. Engrs. Trans., vol. 63, part 3, May 1922, pp. 222–234, 11 figs. Brief consideration of a comprehensive view of all laws brought into operation by two fans working in parallel. See also Min. Inst. of Scotland Trans., vol. 43, Apr. 22, 1922, pp. 22–34, 11 figs.

FIRE PREVENTION

Building Materials Tests. Lessons of Fire Tests, S. H. Ingberg. Clay Worker, vol. 77, no. 7, June 1922, pp. 657–660, 5 figs. partly on p. 661. Brick as fire-resisting material and some results of tests on steel and concrete columns subjected to fire conditions. Paper read before Nat. Brick Mfrs. Assn. convention.

Reinforced Concrete Slab Tests. British Fire Tests on Reinforced Concrete Slabs. Indian Eng., vol. 71, no. 20, May 20, 1922, pp. 278–279, 5 figs. on supp. plate. Dept. of Sci. and Indus. Research four-hour tests, maximum temperature 2000 deg. fahr., followed by 5 min. water application.

FLOORS

Concrete. Hardening Concrete Floors, Edward D. Boyer. Cement & Eng. News, vol. 34, no. 6, June 1922, p. 28. Sometimes defects in workmanship make use of remedies advisable.

FLOW OF WATER

Pipe-Capacity Chart. Chart That Solves Pipe-Capacity Problems, W. F. Schaphorst. Coal Age, vol. 21, no. 24, June 15, 1922, pp. 999–1000, 1 fig. Chart from which velocity that water will travel through a pipe of given diameter may be quickly determined in cu. ft. gals. or lb. per min.

FLOUR MILLS

Machinery. The Machinery of Flour Milling. Eng. Rev., vol. 35, no. 11, May 1922, pp. 370–376, 7 figs. Economics; mechanical aids; cleaning grain; some types of mills.

FLUE-GAS ANALYSIS

Graphical, Use of. New Diagrams for Turning to Account Fuel and Flue-Gas Analyses (Neue Schaubilder zur Auswertung von Brennstoff- und Rauchgasanalysen), Wilhelm Schultes. Wärme, vol. 45, no. 17, Apr. 28, 1922, pp. 213–218, 7 figs. Shows how flue-gas analyses of fuels of known composition can be made use of by means of diagrams and graphic calculations; diagrams for classification of fuels.

FORGING MACHINES

Germany. Recent Forging Machines and Their Application (Neuzeitliche Schmiedemaschinen und ihre Anwendung). Technische Blätter, vol. 12, no. 1, Jan. 7, 1922, pp. 1–3, 13 figs. Discusses machines, especially for research work, railroad shops, and hardware generally.

FOUNDRY EQUIPMENT

Compressed Air. Compressed Air Applied to the Foundry, R. Hoadley Tingley. Compressed Air Mag., vol. 27, no. 6, June 1922, pp. 153–158, 20 figs. Description of some of many air appliances indispensable in modern foundry practice.

[See also CORES.]

FUELS

Coal and Oils. Relative Value of Coal and Oils as Fuels, C. H. Butz. Forging & Heat Treating, vol. 8, no. 6, June 1922, pp. 262–265, 6 figs. Comparison made by means of charts based upon practical operating figures obtained from processes varying in nature from very inefficient furnace to highly efficient boiler.

Utilization on Railways. Utilization of Fuels on Railroads—6th Report of the Commission for the Utilization of Fuels (L'Utilisation des combustibles sur les chemins de fer—Sixieme rapport de la Commission d'utilisation des combustibles). Génie Civil, vol. 80, no. 20, May 20, 1922, pp. 449–453. Effect of electrification of railway lines; character and performance of steam locomotives; production and use of steam; etc.

[See also AUTOMOBILE FUELS, COAL, COKE, GASOLINE, OIL FUEL, PULVERIZED COAL.]

FURNACES, BOILER

Care and Upkeep. Views of Mechanical Engineers in Wyoming Valley as to Proper Care and Upkeep of Boiler Furnaces, D. C. Ashmead. Coal Age, vol. 21, no. 26, June 29, 1922, pp. 1083–1087, 3 figs. Anthracite boiler practice inefficient; some plants install Dutch ovens; combustion arches increase temperature and steadiness of heat; large-size fuel may ruin arches; water softening much needed; fireclay as a mortar.

FURNACES, HEATING

Fuel Economy. Fuel Economy in Heating Furnaces, K. Huessener. Blast Furnace & Steel Plant, vol. 10, no. 7, July 1922, pp. 380–383, 2 figs. New methods to obtain increased production with decreased fuel consumption from regenerative and recuperative furnaces.

G

GAGES

Gage Blocks. Interference Methods for Standardizing and Testing Precision Gage Blocks, C. G. Peters and H. S. Boyd. Scientific Papers Bur. of Standards, no. 436, May 2, 1922, pp. 677–713, 21 figs. Use of interference of light waves makes possible detection of errors within a few millionths of an inch.

Wear, Allowing for. Allowing for Gage Wear, R. Dumas and E. C. Peck. Am. Mach., vol. 56, no. 26, June 29, 1922, pp. 953–954. Discussion of desirability of having fixed tolerance or an allowance for wear; difference of American and British viewpoints.

GALVANIZING

Heat Transmission in. Heat Transmission in the Hot-Galvanizing Process, J. D. Keller. Blast Furnace & Steel Plant, vol. 10, no. 7, July 1922, pp. 371–373, 2 figs. Describing thermal features of process; rate of motion of sheets through bath should vary with sheet thickness if based on factor of heat transmission.

GARAGES

Ramp and Elevator Type. Comparison of Ramp and Elevator Type Garages, Harold F. Blanchard. Bus Transportation, vol. 1, no. 6, June 1922, pp. 331–335, 12 figs. Description of comparative capacities and convenience.

GAS CLEANING

Filtering Process. A New Process For Scrubbing Gases and Vapours, E. Stach. Eng. Progress, vol. 3, no. 6, June 1922, pp. 127–130, 7 figs. Rotary filtering process by Freytag-Messler for removing dust, tar, oil, and other impurities more completely than hitherto.

GAS ENGINES

Navy, Building for. Building Gas Engines for the Navy, S. W. Brinson. Am. Mach., vol. 57, no. 2, July 13, 1922, pp. 45–48, 9 figs. Developing engine

and special plant; equipment of shop; machining engine parts; handling work; assembling engine.

GAS PRODUCERS

Seaboard By-Product Coke Plant. Producer Gas for By-Product Ovens, Freeman D. Lohr. Gas Age-Rec., vol. 49, no. 22, June 3, 1922, pp. 677–681, 8 figs. Description of new plant built to meet increasing demand for gas and decreasing market for coke.

GASOLINE

Cracking Process. Production of Gasoline by Cracking Heavier Oils, E. W. Dean and W. A. Jacobs. Petroleum World, vol. 19, no. 261, June 1922, pp. 225–226 and 228–230, 1 fig. Pressure-distillation and vapor-phase processes; experiments and methods resulting from same. See also Petroleum Times, vol. 7, nos. 180 and 181, June 17 and 24, 1922, pp. 874–875 and 915.

High-Explosive, Process for. New Process Makes High-Explosive Gasoline. Oil Trade Jl., vol. 13, no. 6, June 1922, p. 15. Wm. J. Knox perfects invention which will increase percentage of distillate recovered from crude on large scale.

GEAR-CUTTING MACHINES

Geometric Control. Geometric Control of Gear Cutter Movement, Chester B. Hamilton, Jr. Can. Machy., vol. 27, no. 22, June 1, 1922, pp. 40–41 and 48, 4 figs. Careful grinding of cutters is necessary to maintain proper shape; using mill type of cutter; machines for cutting double-helical gears are of special design.

Spur, Muir Automatic Machine. The Muir Automatic Spur Gear Generating Machine. Machy. (Lond.), vol. 20, no. 506, June 8, 1922, pp. 292–294, 4 figs. Teeth of spur gears are formed with rack-shape cutter which has vertical reciprocating motion across face of gear blank.

Fellows High-Speed Shaper. New Fellows High-Speed Gear Shaper. Machy. (Lond.), vol. 20, no. 507, June 15, 1922, pp. 329–332, 6 figs. Machine that operates with a shaping action and generates gear teeth from gear-shape cutter.

Spur, Hobbing. Cutting Spur Gears by Hobbing. Machy. (Lond.), vol. 20, no. 509, June 29, 1922, pp. 393–398, 5 figs. Setting up gear-hobbing machines; examples from practice; application of multiple-threaded hobs; cutting small pinions.

GEARS

Autopitch. A New Form of Gear. Eng. Production, vol. 4, no. 88, June 8, 1922, pp. 545–548, 24 figs. Development of new type of gear as an attempt to reach requirements of theoretically ideal one; description of extent to which attempt is successful. Abridgment of paper read before Instn. of Engrs. & Shipbuilders.

Helical and Spur. Helical Gears and Spur Gears, W. G. Dunkley. Machy. (Lond.), vol. 20, nos. 500 and 506. Apr. 27 and June 8, 1922, pp. 105–107 and 300–302, 9 figs. April 27: Effect of sliding action on uniform velocity and on relative efficiency. June 8: Contact conditions of spur gears; load distribution and periodical variations; effect of variation of load distribution on uniformity of rotation; effect of increased speed.

GLASS

Composition and Durability. An Examination and Extension of Zulkowski's Theory of the Relation between the Composition and Durability of Glasses, Wm. L. Baillie. Soc. of Glass Technology Jl., vol. 6, no. 21, May 1922, pp. 68–95 and (discussion) 95–101, 1 fig.

GRINDING

Automobile Parts. Grinding in the Automotive Industry. Machy. (N. Y.), vol. 28, no. 11, July 1922, pp. 855–862, 16 figs. Approved methods of grinding such important parts as pistons, piston-rings, piston-pins, cylinders, connecting-rods, crank-shafts, camshafts, gear teeth and spline shafts.

H

HANDLING MATERIALS

Safety in. Making Material Handling Safe, Vernon C. King. Iron Trade Rev., vol. 71, no. 1, July 6, 1922, pp. 29–32, 8 figs. Greatest number of industrial accidents occur in handling of material; use of proper trucking and conveying equipment is aid to safety; discipline and morale are essential factors. Paper presented before Worcester Sec. A.S.M.E.

[See Also COAL HANDLING.]

HANGARS

Airplane. The New Airplane Hangars at the Aerial Port of Bourget, Near Paris (Les nouveaux hangars a avions du port aérien du Bourget, près Paris), Ch. Dantin. Génie Civil, vol. 80, no. 21, May 27, 1922, pp. 465–468, 13 figs. partly on supp. plate. General description of five hangars used by Messageries aériennes Co., Grands Express aériens Co., Franco-Roumaine Co., and Aérienne Française Co.; details of construction.

HARDNESS

Testing. The Ball Hardness Test, Dr. Moore. Metal Industry (Lond.), vol. 20, no. 22, June 2, 1922, pp. 510–513, 1 fig. Indentation tests being purely empirical should specify conditions. Features of Brinell test and Meyer's laws. Paper presented before Inst. of Metals.

HEAT TRANSMISSION

Cylinder Walls. Heat Transmission Through Cylinder Walls of Internal-Combustion Engines (Wärme Durchgang durch die Zylinderwandungen von Verbrennungs-Maschinen), Schlachter. Motor u. Auto, vol. 19, nos. 7, 8 and 9, May 1, 10 and 20, 1922, pp. 97–100, 113–116 and 129–131, 8 figs. Discusses transmission of heat from one medium to another, and develops formula for calculation; transmission of heat from gas to metal walls; examines heat transmission on mathematical basis.

Measurement. American Heat Transmission Measurement by the Two-Plate System (Amerikanische Wärmedurchgangsmessungen nach der Zweiplattenmethode), Max Jakob. Zeit. für die gesamte Kälte-Industrie, vol. 29, no. 5, May 1922, pp. 83–87, 3 figs. Recent work carried out by Bur. of Standards and Am. Soc. Heat. & Vent. Engrs.

HEATING AND VENTILATING

Cleveland Public Auditorium. Ventilating Equipment of Cleveland's Public Auditorium, M. A. Boyd. Heat. & Vent. Mag., vol. 19, no. 6, June 1922, pp. 33–40, 9 figs. Methods followed in handling air supply for largest plastered structure in world.

HEATING, STEAM

Building Heating Plant. World's Largest Gas Heating Plant, S. S. Fyfe. Gas Age-Rec., vol. 49, no. 25, June 24, 1922, pp. 765–768, 3 figs. Gas-fired steam boilers at Los Angeles; heats building of 3,000,000 cu. ft., using mixed natural and artificial gas.

General Fire Extinguisher Co. Heating System of the General Fire Extinguisher Co., Chas. L. Hubbard. Power Plant Eng., vol. 26, no. 12, June 15, 1922, pp. 591–595, 10 figs. Steam is generated at high pressure and used only for heating. Power is purchased from an outside source.

HOISTING ENGINES

Steam and Air Combination. Combination Steam and Air Hoist, R. C. Demary. Nat. Engr., vol. 26, no. 6, June 1922, pp. 244–246, 5 figs. Description of twin tandem compound with Corliss-type valve gear; high-pressure cylinders which are used for compressing air.

HOISTS

Skip. Elevating Coke by Skip Hoist. Gas Age-Rec., vol. 49, no. 22, June 3, 1922, pp. 683–684 and 687, 5 figs. Taking coke from small cars to elevated bins by means of automatic device; straight-up lift eliminates consideration of belt conveyor.

HYDRAULIC TURBINES

Impellers. Minimum Number of Blades and Inlet Diagram of Modern Turbine Impellers (Die Minimalschaufelzahl und das Eintrittsdiagramm für moderne Stauturbinenlaufräder), Hugo Marschner. Zeit. des Österr. Ingenieur- u. Architekten-Vereines, vol. 74, no. 15–16, Apr. 14, 1922, pp. 67–69, 6 figs. Present turbine systems; arrangement of rotating blades, and calculation of minimum number; minimum space between blades.

Radial Suction. Radial Suction Turbines (Die Saugstrahlturbine), Hans Baudisch. Elektrotechnik u. Maschinenbau, vol. 40, no. 25, June 18, 1922, pp. 289–291, 1 fig. Calculation of useful work, losses due to friction and eddies, comparison with Kaplan turbine, etc.

HYDROELECTRIC PLANTS

France. Hydroelectric Plant of Baumont-Monteaux (Usine hydro-électrique de Beaumont-Monteux), J. Reyval. Révue Générale de l'Électricité, vol. 11, no. 21, May 27, 1922, pp. 781–790, 17 figs. A central station situated at confluence of Isère and Rhone; will supply current to industrial works; general description of parts of plant and engineering work connected with it.

Hydroelectric Plant of Beaumont-Monteaux (Usine hydro-électrique de Beaumont-Monteux), Jacques Suet. Révue Générale de l'Électricité, vol. 11, no. 22, June 3, 1922, pp. 817–829, 18 figs. Describes electric equipment, including alternators, exciters, transformers, switchboard; current is stepped from 5,500 to 120,000 volts.

New Brunswick. New Hydro Plant in New Brunswick. Elec. News, vol. 31, no. 11, June 1, 1922, pp. 34–39, 9 figs. Unique installation just completed at Musquash River, near St. John; actually two plants in one; work of New Brunswick Power Commission.

Queenston-Chippawa, Canada. Arrangement for Handling 500,000-Kw. Load from Queenston Plant. Elec. World, vol. 79, no. 25, June 24, 1922, pp. 1261–1263, 2 figs. Most economical utilization of water power available and protection against interruption of service were chief factors influencing design of this new station of Hydroelectric Power Commission of Ontario.

Queenston-Chippawa Hydro Development Largest in the World. Power, vol. 55, no. 26, June 27, 1922, pp. 1000–1006, 9 figs. Initial installation five 55,000-hp. hydroelectric units; 305 ft. of 327-ft. head between Lake Erie and Lake Ontario effective on turbines; water carried through concrete-lined canal designed for possible ultimate capacity of 600,000-hp.

Semi-Outdoor. Semi-Outdoor Hydro-Electric Plant with Backwater Suppressor, John A. Sirnit. Elec. World, vol. 79, no. 23, June 10, 1922, pp. 1161–1164, 5 figs. Mitchell Dam development of the Alabama Power Company will involve an entirely new principle in hydroelectric construction. Results of long series of experiments in backwater suppression.

Switzerland. Hydroelectric Plant of Fully (Valais, Switzerland) Using a Head of 1,650 m. [Usine hydro-électrique de Fully (Vailis, Suisse), utilisant une chute de 1.650 mètres], Ch. Dantin. Génie Civil, vol. 80, nos. 18 and 19, May 6 and 13, 1922, pp. 393–397 and 423–427, 29 figs. partly on supp. plate. May. 6: Describes civil-engineering features, damming of Fully Lake, pressure piping, etc. May 13: Electric generating machinery; turbine regulators; pipe lines.

I

INDICATORS

Indicator Diagrams of Compound Engine. Indicator Diagrams of Compound Engines. Power, vol. 56, no. 2, July 11, 1922, pp. 55–58, 10 figs. Classification of engine types; fixed and variable low-pressure cut-off. Other characteristics which determine proper setting of valves.

Micro, for High-Speed Engines. The Collins Micro-Indicator for High-Speed Engines. Engineering, vol. 113, no. 2945, June 9, 1922, p. 716, 3 figs. Description of instruments which within half a minute will produce on card ten successive indicator diagrams of performance of a high-speed engine.

INDUSTRIAL MANAGEMENT

Business Depression Cycle. Facts May Prevent Depressions, Ernest F. Dubrul. Iron Trade Rev., vol. 70, no. 25, June 22, 1922, pp. 1791–1794. Ignorance of business cycles brings reversals; burden rests upon management of modern industry to study basic factors; should contribute to general store by frank publicity about its own conditions.

Cost Explanation for Employees. Interpreting the Corporation to the Workers, C. M. Ripley. Elec. World, vol. 79, no. 25, June 24, 1922, pp. 1281–1282, 2 figs. Value of explaining distribution of costs to employees.

Manager's Problems. Solving the Manager's Present Day Problems, John H. Van Deventer. Indus. Management, vol. 64, no. 1, July 1922, pp. 1–3. Barriers to improved methods and how to overcome them.

Planning and Controlling, Chart for. Planning and Controlling Work in the Assembling Department of a French Shop, E. Jullien. Am. Mach., vol. 56, no. 25, June 22, 1922, pp. 932–933, 6 figs. Work plotted on revolving calendar and always under control of planning department; forms used for assembly specifications and piece-work tickets.

Psychosis of Industry. The "Psychosis" of Industry, Frank Mason Harris. Indus. Management, vol. 64, no. 1, July 1922, pp. 18–23. Application of psychoanalysis methods in relieving friction between employer and worker.

Purchase Controlled by Output Records. Making Output Records Control Material Purchases, Kenneth Coggeshall. Indus. Management, vol. 64, no. 1, July 1922, pp. 6–11, 23, 6 figs. Practical procedure for conservative purchasing with materials in stock bought at former high levels.

Shop-Record Keeping. Record Keeping on Dies, Tools and Scrap, Geo. H. Koskey. Forging & Heat Treating, vol. 8, no. 6, June 1922, pp. 279–282, 6 figs. Ideas as to data which can be kept and discussion of die bonus and die piecework.

INTERNAL-COMBUSTION ENGINES

Fuels. Research Aimed at Solution of Fuel Problem, Herbert Chase. Automotive Industries, vol. 46, no. 26, June 29, 1922, pp. 1412–1418, 5 figs. Co-operation of automotive and petroleum industries; new knock preventive announced by General Motors; lubricating problems also discussed.

The Value of Gas Engine Fuels, Letson Balliett. Min. Rev., vol. 24, no. 5, June 15, 1922, pp. 14–15. Exposition of impossible claims to increase heat values of hydrocarbon fuels; use of fuel oil in blacksmith's shop.

Combustion. Combustion Research—An Aid to Better Performance, Herbert Chase. Automotive Industries, vol. 46, no. 23, June 8, 1922, pp. 1253–1265, 2 figs. Internal-combustion engines; factors affecting detonation; flame propagation and related subjects examined by various investigators.

Reversing Turbine for Marine. The Starting and Reversing of Marine Internal-Combustion Engine with the Aid of Compressed-Air Turbines (Ueber das Anlassen und Umsteuern von Schiffs-Verbrennungskraftmaschinen mit Hilfe von Druckluftturbinen), Paul Praetorius. Schiffbau, vol. 23, nos. 28, 29, 30, 32, 34 and 35, Apr. 12, 19, 26, May 10, 24, and 31, 1922, pp. 851–857, 879–886, 911–915, 959–963, 1007–1012 and 1035–1040, 19 figs. Describes reversing turbine developed by author for a 60-hp. four-cylinder, four-cycle Diesel engine, points out its advantages and gives results of tests; comparison with other reversing systems.

Sproule. The Sproule Internal Combustion Engine. Oil Eng. & Finance, vol. 1, no. 81, March, 4 1922, pp. 277–279, 1 fig. Description of engine in which it is claimed that difficulties of limited flexibility, low efficiency, and lack of easy reversibility are almost completely overcome.

Still System for Marine. The Still System of Internal-Combustion Engine for Marine Purposes, F. Leigh Martineau. Steamship, vol. 33, no. 396, June 1922, pp. 414–416. Description of system which is applicable to several types of engines. Read before Inst. Mar. Engrs.

[See also AIRPLANE ENGINES, AUTOMOBILE ENGINES, DIESEL ENGINES, GAS ENGINES, OIL ENGINES.]

IRON

Metallography. Influence of Graphite on Iron, J. W. Bolton. Foundry, vol. 50, no. 11, June 1, 1922, pp. 436–443, 19 figs. Theories advanced for varying effects of graphite on cast iron and semi-steel explain states in which it is found; causes are analyzed; micrographs illustrate points.

IRON INDUSTRY

Nord-Paris Co. Plant. The Works of the Nord-Paris Company. Engineering, vol. 113, no. 2945, June 9, 1922, pp. 708–709, 2 figs. Description of steel works, iron foundry, large machine shop, and auxiliary buildings covering some 50,000 sq. yd.

IRON ORE

Chromite. Chromite for the Manufacture of Ferro-Chrome, J. A. Holden. So. African Min. & Eng. Jl., vol. 33, no. 1595, Apr. 22, 1922, pp. 1120–1121, 1 fig. Rhodesian and new Caledonian ores contrasted; varieties suitable for electrometallurgical smelting and some features of process.

Electric-Furnace Reduction. Electrothermic Reduction of Iron Ores and Pyrites (Sulla riduzione elettrotermica dei minerali di ferro e delle ceneri di pirite), Stefano Pagliani. Forno Elettrico, vol. 3, no. 12, Dec. 15, 1921, pp. 168–183, 13 figs. Development of direct reduction of iron ore in electric furnace; summary description of the various furnaces and their working.

IRON, PIG

Silicon, Lower. Foundries Can Use Lower Silicon Irons, V. A. Dyer. Iron Age, vol. 109, no. 25, June 22, 1922, pp. 1749–1750. Blast furnace-men would be relieved by lessened demand for high-silicon pig; call for high-phosphorus iron may be overdone also.

L

LEATHER

Drying Artificially. Artificial Drying of Leather, M. Hirsch. Eng. Progress, vol. 3, no. 6, June 1922, pp. 123–125, 5 figs. Arrangement for regulating admission of air according to progress of drying and proportioning recirculated and fresh air as drying proceeds.

LIGHTING

Industrial. Industrial Lighting: Ideal Requirements (Legislative and Otherwise) and Practical Solutions, L. Gaster. Illuminating Engr., vol. 15, no. 2, Mar. 1922, pp. 74–88, 8 figs. Consideration of four essentials for ideal lighting and discussion of code. Paper read before Illuminating Eng. Soc.

LIME

Plants. The New Rockland Lime Plant, Nathan C. Rockwood. Rock Products, vol. 25, no. 12, June 17, 1922, pp. 35–44, 36 figs. Six continuous-discharge, gas-fired mount design kilns of which five turn out 130 tons of lime in 24 hours.

A Plant Ahead of Its Time, Clinton S. Darling. Rock Products, vol. 25, no. 12, June 17, 1922, pp. 59–68, 32 figs. Rotary kiln for dry or semi-wet burning, with 175 ft. flame; remarkable flexibility to make every lime product at Am. Lime & Stone Co.'s plant.

LOCOMOTIVE BOILERS

Circulation, Effect on Efficiency. Effect of Circulation on Locomotive Boiler Efficiency, F. G. Lister. Ry. Rev., vol. 70, no. 22, June 3, 1922, pp. 787–790. Needed improvements in design for effecting better circulation, covered in paper presented at annual convention of Int. Ry. Fuel Assn. 1922.

LOCOMOTIVES

Fire Box, Water-Tube. Development of a Practical Water-Tube Locomotive Fire Box, D. L. Kiss. Ry. Rev., vol. 70, no. 24, June 17, 1922, pp. 900–908, 16 figs. Hungarian state railways successfully operating locomotives equipped with Broton type boilers; use of water purifiers an important factor.

Design and Equipment. Current Questions of Locomotives Design and Equipment. Ry. Rev., vol. 70, no. 25, June 24, 1922, pp. 982–987, 1 fig. Am. Ry. Assn. Committee on locomotive construction considers relative merits of locomotive types and details in design. (Abstract.)

Fuel Economy. Effect of Tonnage Rating and Speed on Fuel Consumption, J. E. Davenport. Ry. Rev., vol. 70, no. 22, June 3, 1922, pp. 777–782, 10 figs. Practical interpretation of results of laboratory tests conducted in Pennsylvania Locomotive testing plant, showing heavy slow-speed trains to be most economical. Papers read before Int. Ry. Fuel Assn.

Locomotive Fuel—The Life Blood of Transportation, G. M. Basford. Ry. Rev., vol. 70, no. 22, June 3, 1922, pp. 782–785, 2 figs. Salient points in address at annual convention of Int. Ry. Fuel Assn.

Headlights, Electric. Effect of Design on Headlight Maintenance, R. Wayne Cargo. Ry. Age, vol. 73, no. 1, July 1, 1922, pp. 31–32, 4 figs. Cost of turbine-generator operation calls for careful consideration in selection of equipment.

Mallet for Pekin-Suiyuan. Heavy Mallet Locomotive for Pekin-Suiyuan. Ry. Mech. Engr., vol. 96, no. 6, June 1922, pp. 305–307, 5 figs. Largest locomotives exported or operated outside of U. S. now in service in China.

Mikado for Michigan Central. Lima Builds a New Mikado for the Michigan Central. Ry. Rev. vol. 70, no. 24, June 17, 1922, pp. 910–911. Locomotive 8000 recently placed in service weighs 334,000 lb. and exerts tractive effort of 63,500 lb. without booster.

Southern Pacific, 2-10-2. 2-10-2 Type Locomotive for the Southern Pacific. Railroad Herald, vol. 26, no. 7, June 1922, pp. 19–21, 2 figs. Description of locomotive of which 50 have recently been ordered.

Fifty More New Freight Locomotives for the Southern Pacific. Ry. Rev., vol. 70, no. 24, June 17, 1922, pp. 897–900, 5 figs. Southern Pacific motive power reflects evolution of 2-10-2 type; new locomotive equipped with Boosters and feedwater heaters.

Superheater. The New Locomotives of the Halberstadt-Blankenburg Railroad Company (Die neuen Lokomotiven der Halberstadt-Blankenburger Eisenbahn-Gesellschaft), Gustav Hammer. Glasers Annalen, vol. 90, no. 11, June 1, 1922, pp. 192–200, 10 figs. Describes new type 1E1 superheater locomotive with tender, built by Borsig, which shows reduction in fuel consumption and considerable increase in tractive effort.

The Superheater Locomotive—Its Lubrication. Lubrication, vol. 8, no. 5, May 1922, pp. 49–60, 10 figs. Important features in operation and lubrication in connection with these.

Uniflow. Recent Developments in the Unaflow Locomotive. Ry. Age, vol. 72, no. 25, June 24, 1922, pp. 1727–1730, 7 figs. Exhaust ejector effect overcomes handicap of high compression and reduces size of cylinders.

LUBRICATING OILS

Frictional Loss, Testing. A Practical Way to Test Lubricating Oils for Frictional Losses, W. F. Osburne Power, vol. 55, no. 26, June 27, 1922, pp. 1010–1011. Readings to be taken; heat carried away from bearings; considerations other than bearing temperatures.

Storing and Handling. The Storage and Handling of Lubricating Oil, Allen F. Brewer. Indus. Management, vol. 64, no. 1, July 1922, pp. 27–30, 4 figs. Application of engineering principles to elimination of waste and obtaining maximum efficiency.

Voltol. The Production of Voltol. Eng. Progress, vol. 3, no. 6, June 1922, pp. 121–122, 2 figs. Process of making high-viscosity oil from thin cheap ones under effect of electrical glow discharges in rarefied gas.

LUBRICATION

Lubricants and. Lubrication and Lubricants, W. A. Ludwick. Steam, vol. 29, no. 6, June 1922, pp. 157–164. Consideration of straight-run mineral, blended mineral, compounded and animal oils; greases; selection of lubricants.

Petroleum. Petroleum and Lubrication, E. A. Evans. Oil Eng. & Finance, vol. 1, no. 13, Apr. 8, 1922, pp. 434–436. Consideration of true friction and proper specifications for oil to overcome same; constitution of film; carbonization; emulsion. Paper read before Inst. Mar. Engrs.

M

MACHINE GUNS

Hotchkiss Company, Levallois Works. The Levallois Works of the Hotchkiss Company. Engineering, vol. 113, no. 2945, June 9, 1922, pp. 710–711, 4 figs. Description of plant arranged for fine machine work.

MALLEABLE CASTINGS

Manufacture. Production of Malleable Castings and the Triplex Process (La fabrication de la Fonte malleable et le Procede Triplex), T. Levox. Fonderie Moderne, no. 6, June 1922, pp. 169–173. Composition and properties of malleables produced by triplex and other processes; electric production of malleable castings in continuous furnace.

MALLEABLE IRON

Manufacture. Malleable Anneals Not Packed, E. K. Smith. Foundry, vol. 50, no. 11, June 1, 1922, pp. 457–458, 2 figs. Pot with flange at both ends is developed to prevent gases from entering and attacking castings; temperature must be kept low to eliminate warping when castings are not supported.

Standardization. Standardizing Malleable Iron (Ueber die "Normung" von Temperguss), Rudolf Stotz. Giesserei-Zeitung, vol. 19, nos. 20 and 21, May 16 and 23, 1922, pp. 301–303 and 319–322, 3 figs. May 16: Dependence of tensile strength on thickness of wall and methods of production; gives figures for tensile strength from various foundries. May 23: Chemical composition and physical tests; shrinkage; etc.

MATERIALS

Testing Method. The Sliding Cone as Basis for Testing Materials (Die Rutschkegelbildung all Grundlage ze das Materialprüfwesen), Friedr. Riedels Zeit. des Vereines deutscher Ingenieure, vol. 66, no. 23, June 10, 1922, pp. 566–571, 17 figs. Defects of present theory of stresses in materials; formulates new laws on basis of experiment, and discusses their application to testing of materials.

METALLOGRAPHY

Preparation of Metal. Preparation of Metal for Microscopic Examination, Wm. Campbell. Chem. & Met. Eng., vol. 26, no. 25, June 21, 1922, pp. 1163–1164. Preparation of specimens, development of structures for various samples.

METALS

Fatigue. Fatigue of Metals, C. E. Stromeyer. Iron & Coal Trades Rev., vol. 104, no. 2831, June 2, 1922, pp. 822–824, 2 figs. Empirical law by which fatigue limit may be obtained by direct measurement quickly and fatigue coefficient within one-half hour. (Abstract.) Paper read before So. Wales Inst. of Engrs.

Calorizing. Calorization (Note sur la calorisation), Léon Guillet. Bul. Technique du Bureau Veritas, vol. 4, no. 4, Apr. 1922, pp. 83–86, 3 figs. Discusses methods of protecting metallic articles, especially calorization or coating by means of aluminum by Schoop spraying process.

Casting. The Casting of Metals, Thomas Turner. Brass World, vol. 18, no. 6, June 1922, pp. 191–195. Consideration of melting and molding of metals as a whole with special attention to non-ferrous alloys. Lecture before Inst. of Metals.

Cold Rolling and Drawing. The Process of Cold Rolling and Drawing and Its Consumption of Power (Der Kaltwalz- und Ziehvorgang und sein Leistungsverbrauch), L. Weiss. Zeit. für Metallkunde, vol. 14, no. 4, Apr. 1922, pp. 160–172, 18 figs. Develops formulas for calculating power required for cold rolling and applies results to wire drawing, giving examples.

Properties, Effect of Temperature on. The Effect of Temperature on Some of the Properties of Metals, F. C. Lea. Engineering, vol. 113, no. 2948, June 30, 1922, pp. 829–832, 11 figs. Results of experiments on critical points; tensile tests at from 40 deg. to 1000 deg. cent. tests on Armco iron; table showing properties of iron and certain steels at various temperatures; alloys of aluminum and copper. Paper read at Paris meeting of I.M.E.

METRIC SYSTEM

Arguments Against Adoption. Standardization and the Metric System (La standardizzazione e la serie metrica standard), Narciso Desirello. Industria, vol. 36, no. 9, May 15, 1922, pp. 163–167, 6 figs. Concludes that metric system, although perfect theoretically, is entirely inadequate for practical use and modern industrial exigencies.

MILLING MACHINES

Horizontal. A New Horizontal Milling Machine (Neue Wagerecht-Fräsmaschinen), M. Naumann. Ziet. des Vereines deutscher Ingenieure, vol. 66, no. 20, May 20, 1922, pp. 486–490, 33 figs. Describes new universal type built by Saxon Milling Machine Works, Chemnitz, and gives particulars of operation.

MINE LOCOMOTIVES

Germany. Mine Locomotive Conveying in the Ruhr District (Der Stand der Grubenlokomotivdörderung im Ruhrbezirk), O. Gunderloch. Glückauf, vol. 58, nos. 20, 21 and 22, May 20, 27 and June 3, 1922, pp. 589–592, 616–622, and 653–657, 25 figs. Describes various types of benzol, wired electric, electric accumulator, and compressed-air locomotives; their management and cost of operation.

MOLDS

Ingot, Production. Production of Molds for Steel Works (Ueber die Herstellung von Stahlwerkskokillen), A. Riebold. Giesserei-Zeitung, vol. 19, no. 15, Apr. 11, 1922, pp. 239–241. Thickness of wall and relation to size of ingot.

MOTION PICTURES

Films. Chemical Production and Treatment of Films (Die chemische Herstellung und Behandlung von Filmen), S. Halen. Kunststoffe, vol. 12, no. 10, May 2, 1922, pp. 73–76. Discusses production from nitrocellulose, copper oxide, ammonia cellulose, viscose, cellulose hydrates in caustic alkali, etc., also sensitizing of gelatin layer.

MOTOR BUSES

Design. What Constitutes a Perfect Motor Bus? G. A. Green. Automotive Industries, vol. 46, no. 25, June 22, 1922, pp. 1364–1371, 14 figs. Controlling design factors are safety, comfort, and minimum operating cost. They can be obtained with low center of gravity, wide frame, track and spring centers and effective braking. Short turning radius is necessary, together with clear vision for driver (Excerpt.) Paper read before Soc. Automotive Engrs.

Design and Operation. Motor Bus Design and Operation, G. A. Green. Bus Transportation, vol. 1, no. 7, July 1922, pp. 369–375, 13 figs. Construction of single-deck and double-deck vehicles; factors involved in minimum operating cost; maximum accessibility requires separate unit form of chasis construction. (Abstract.) Paper read before S.A.E.

MOTOR TRUCKS

Parts Inspection. Rigid Inspection One of Rules at this Plant. Can. Machy., vol. 27, no. 25, June 22, 1922, pp. 47–48, 2 figs. Practice at Nat. Steel Car Corp., Hamilton, Ont. Parts purchased from outside sources are tested before leaving place of manufacture; further test given at Hamilton factory; jigs and fixtures are extensively used.

N

NICKEL ALLOYS

Chromel. Chromel Castings, Bars, Wire and Ribbons, E. F. Lake. Brass World, vol. 18, nos. 5 and 6, May and June 1922, pp. 158–161 and 165–167, 9 figs. Nickel-chromium alloy with higher chromium content than is found in others; its uses.

Nickel-Chromium Casting. Cast Nickel-Chromium Alloys, E. F. Lake. Foundry, vol. 50, no. 11, June 1, 1922, pp. 452–454, 6 figs. Metals are melted

in induction, arc and crucible-type electric furnaces; purity found to be essential; iron added to one of alloys; occluded gases a menace in melting.

O

OIL ENGINES

Cold-Starting Crude. The Brotherhood Cold-Starting Crude Oil Engine. Engineering, vol. 113, no. 2946, June 16, 1922, pp. 746–748, 12 figs. Horizontal 4-cycle type started by compressed air on regular fuel. Will operate after starting on any grease that can be pumped.

OIL FUEL

Burning Efficiency. How to Burn Fuel Oil Efficiently, Jos. W. Hays. Refrigeration, vol. 30, no. 2, Apr. 1922, pp. 31–36. Correct conditions of furnace, atomizing burner, air supply and operation.

OIL INDUSTRY

California. Oil Industry in California, Henry M. Payne. Eng. & Min. Jl.-Press, vol. 113, no. 25, June 24, 1922, pp. 1099–1103, 3 figs. Extensive records by state of operations; "peg models;" standard methods employed.

Records, Forms for Keeping. Forms for Keeping Records. Oil Field Eng., vol. 24, no. 5, May 1922, pp. 130–136. Suggestions for preparation of sheets on which to keep records, and summary of information that should be collected.

OIL SHALES

Esthonian. The Chemical Properties of Esthonian Shales. Petroleum Times, vol. 7, no. 178, June 3, 1922, pp. 777–778. Some facts about most successful development in this field and unusually rich properties of shale.

Kukkersite, the Oil Shale of Esthonia, E. H. Cunningham. Petroleum World, vol. 19, no. 261, June 1922, pp. 255–259. Facts about occurrence and development of one of richest oil shales known.

OPEN-HEARTH FURNACES

British Practice. British Open-Hearth Furnace Practice. Iron Age, vol. 110, no. 2, July 13, 1922, pp. 75–78, 2 figs. Higher temperatures and more rapid working aimed at in proposed design of a 100-ton furnace; reduction of heat losses great desideratum.

Design Improving. Improving Open-Hearth Design, Willis McKee. Iron Trade Rev., vol. 70, no. 26, June 29, 1922, pp. 1865–1868, 5 figs. Blow-torch principle insures better combustion; proposal to introduce gas into uptakes without regeneration; improved design is resulting in greatly increased output, better steel and longer life of furnace.

Valves. Gas and Air Valves for Open Hearth Furnaces, Wm. C. Bulmer. Blast Furnace & Steel Plant, vol. 10, no. 6, June 1, 1922, pp. 302–306, 4 figs. Discussion of development of various types of valves for which each inventor claims some superiority.

ORDNANCE PLANTS

U. S. Navy. Naval Gun Factory at Washington, Sidney G. Koon. Iron Age, vol. 110, no. 2, July 13, 1922, pp. 87–90, 3 figs. Exceptionally massive machine tools for production of heaviest naval ordnance; subsidiary work of great importance.

OVENS

Electric, Enameling. Electric Ovens Are A Good Investment, West S. Scott. Elec. Rev. & Indus. Engr., vol. 80, no. 6, June 1922, pp. 275–277, 4 figs. Flexibility and ease of heat control, freedom from gases and low maintenance are among advantages of various examples discussed.

OXY-ACETYLENE CUTTING

Cutting Machines. Oxy-Acetylene Cutting Machine, I. William Chubb. Am. Mach., vol. 56, no. 25, June 22, 1922, pp. 929–931, 5 figs. Mechanically guided torch cuts intricate shapes at great speed; gas pressure and rate of torch travel regulated to suit work.

Machine, Efficiency of. Efficiency of Machine Cutting, Fred J. Maeurer. Acetylene Jl., vol. 23, no. 12, June 1922, pp. 587–595, 25 figs. Cutting with oxy-acetylene torch can be made to approach very closely maximum theoretical efficiency. Paper read before Am. Welding Soc

Underwater. The Underwater Torch Makes Good. Pacific Mar. Rev., vol. 19, no. 6, June 1922, pp. 337–339, 5 figs. Temperature of 6000 deg. fahr. enables diver to cut metals at any depth to which he can descend.

OXY-ACETYLENE WELDING

Foundries. Oxy-Acetylene Cutting and Welding in Foundry, G. O. Carter. Can. Foundryman, vol. 13, no. 6, June 1922, pp. 36–39. Piped oxygen and acetylene installations are recommended for large foundries. Many uses, such as cutting steel risers and welding gray iron.

P

PAINTS

Exposure Tests. Miscellaneous Exposure Tests, Henry A. Gardner. Educational Bur., Paint Manufacturers' Assn. of U. S., no. 153, June 1922, pp. 282–313, 12 figs. Durability tests on paints applied by spray gun vs. hand brush; three-year exposure results on Atlantic City panels; and tests on metal power paint, titanium oxide pigment and antimony oxide pigment.

PAPER MANUFACTURE

New Paper From Old. Making New Paper From Old Paper Stock, Sidney D Wells. Paper, vol. 30, no. 14, June 7, 1922, pp. 7–10. Deinking processes for old newspapers and use of bentonite as peptizing agent.

PAPER MILLS

Machines, High-speed. Developments in High Speed Machines. Paper, vol. 30, no. 12, May 24, 1922, pp. 7–11. Effect of late developments in making paper by high-speed processes.

PIPE, CAST-IRON

Centrifugal Process. Cast Iron Water Pipe Made by de Lavaud Process. Can. Foundryman, vol. 13, no. 5, May 1922, pp. 26–27, 33, 2 figs. Melted metal poured into revolving mold is deposited by centrifugal force against wall of mold; makes dense grained homogeneous casting.

Failure, Causes of. Causes of Failure in Cast Iron Pipe, F. A. McInnes. Eng. & Contracting, vol. 62, no. 24, June 14, 1922, pp. 563–564. Quality of pipe line; permissable sulphur content; importance of analyses of iron.

PIPES

Coating for Cast Iron and Steel. The Right Kind of Coating for Pipe, Wm R. Conard. Fire & Water Eng., vol. 71, no. 25, June 21, 1922, pp. 1107–1108 and 1122, 1 fig. Suggestions for durable and efficient coating that will insure longer life for cast-iron or steel pipe. From paper read before Convention of Am. Water Wks. Assn.

Tar Coating for. Present Day Tars for Pipe Coatings, Wm. R. Conard. Can. Engr., vol. 42, no. 22, May 30, 1922, pp. 560–561. Dr. Angus Smith's solution; standard specification for pipe coatings; quality of tar used at present time; objective for research work. Paper read at Annual Mtg. Am. Water Wks. Assn.

PISTON RINGS

Quantity Production. Quantity Production of High-Grade Piston Rings (Massenerzeugung höchstwertiger Kolbenringe), C. Irresberger. Stahl u. Eisen, vol. 42, no. 22, June 1, 1922, pp. 841–845, 12 figs. Demands made on piston rings; sand and permanent molds for casting; centrifugal casting process; etc.

PISTONS

Aluminum. Aluminum Pistons (A propos des Pistons en aluminium), Frank Jardine and Ferdinand Jehle. Technique Automobile et Aérienne, vol. 13, no. 117, 1922, pp. 54–59, 9 figs. Design and operation; measurment of temperature, tolerance, etc.

PLANERS

Foundations. Second-Story Planer Foundations, A. E. Robinson. Am. Mach., vol. 56, no. 25, June 22, 1922, pp. 917–919, 4 figs. How American Tool Works supports its planer department upstairs; concrete slabs for foundations; methods of leveling and straightening long planer beds.

PLATES

Rectangular, Stress in. Method for Approximate Static Calculation of the Bending Stress of Rectangular Plates (Verfahren zur angenäherten statischen Berechnung biegefester rechteckiger Platten), Ludwig Hotopp. Beton u. Eisen, vol. 21, nos. 6 and 8, Apr. 5 and May 9, 1922, pp. 95–97 and 116–119, 8 figs. Discusses distribution of stresses and gives examples and calculations.

POWER PLANTS

Chile. The Power Works of Chuquicamata (Los talleres y fuerza motriz de Chuquicamata). Ingenieria Internacional, vol. 8, no. 2, Aug. 1922, pp. 89–94, 3 figs. Production of power for mines and metallurgical works; a central heating station which burns oil and uses salt water.

Management. Power Station Management. J. S. Thomson. Iron & Coal Trades Rev., vol. 104, no. 832, June 9, 1922, pp 847–848. Sixteen economic areas suggested for England; most of power must come from thermal efficiency; gas and electric typical stations; automatic operations; steam considerations; electrical details.

Paper Mills. The Provincial Paper Mills, Power Plant, T. H. Fenner. Power House, vol. 15, no. 11, June 5, 1922, pp. 19–23, 8 figs. Interesting features of boiler room and facilities for enlargement of plant.

Wheeling Steel Corporation. Wheeling Steel Corporation Construct New Power Plant, Thos. G. Estep. Blast Furnace & Steel Plant, vol. 10, no. 6, June 1, 1922, pp. 329–337, 11 figs. Detailed description of modern power station constructed at Whitaker-Glessner plant, Wheeling, W. Va.; many unusual features mark plant.

PRESSES

Power, Crankshaft Design. Designing Power Press Crankshafts, Wm. J. Smith. Eng. Production, vol. 4, no. 87, June 1, 1922, pp. 509–513, 5 figs. Details of calculations and formulas involved.

PULVERIZED COAL

Boiler Firing. Progress in Pulverized Fuel Firing, F. J. Crolius. Blast Furnace & Steel Plant, vol. 10, no. 6, June 1, 1922, pp. 337–339. Code recommended for adoption by Carnegie Steel Company in handling of pulverized coal, presented; many points of unnecessary danger have been eliminated.

Danger of Explosion in Pulverized Coal Firing, (Die Explosionsgefahr bei Kohlenstaubfeuerungen), Mathtiass. Technische Blätter, vol. 12, no. 22, June 3, 1922, pp. 225–227. Direct and indirect methods of firing; safety regulations to avoid explosions.

Powdered Fuel under Steam Boilers. Iron & Coal Trades Rev., vol. 104, no. 2, 832, June 9, 1922, p. 858. Summary of results of five boiler tests with pulverized Illinois coal, made by Milwaukee Elec. Ry. & Light Co.

Combustion. Dangers of Coal Dust (Die Gefahren des Brennstaubes), A. B. Helbig. Feuerungstechnik, vol. 10, no. 17, June 1, 1922, pp. 188–190. Discusses in detail process of combustion and shows that with ordinary care there is no danger of explosion.

Fire Hazards. Fire Hazards in Plants Using Pulverized Coal, L. D. Tracy. Blast Furnace & Steel Plant, vol. 10, no. 7, July 1922, pp. 395–399. Various cases where fires and explosions originated from improper handling of pulverized coal; many hazards connected to apparatus used for pulverizing.

Stationary Boilers. Use and Abuse of Powdered Fuel for Stationary Boilers, John E. Muhlfeld. Blast Furnace & Steel Plant, vol. 10, no. 6, June 1922, pp. 353–355. Any great advance in combined boiler and furnace efficiency will depend largely upon full utilization of radiant heat.

PUMPING PLANTS

Land Drainage. Pumping Plants for Land Drainage, L. C. Craig. Can. Engr., vol. 42, no. 21, May 23, 1922, pp. 525–527. Reclaiming land in Mississippi River valley; electrically driven centrifugal pumps often used for drainage work; advantage of Diesel engines.

PUMPS

Endless-Chain. The "Aquatole" Endless-Chain Pump. Engineering, vol. 113, no. 2948, June 30, 1922, pp. 827–828, 9 figs. Installation of Aquatole liquid lifter which has capacity of 20,000 gal. per hr. with driving pully speed of 350 r.p.m.; efficiency of 55 per cent is attainable and ease of setting up and variety of liquid that can be handled are desirable features.

Gasoline, for Aircraft. The "Sylphon" Petrol Pump. Flight, vol. 14, no. 24, June 15, 1922, p. 344, 2 figs. Eliminates troubles arising from glands and their packing, and gives maximum discharge pressure at high speeds and sufficient delivery of fuel at any speed.

Hydrautomat. The Hydrautomat. Elec. Times, vol. 61, no. 1600, June 15, 1922, pp. 573–574, 2 figs. Invention whereby water is lifted through open and closed tanks by small water stream.

Valveless Reciprocating. A Valveless Reciprocating Pump. Colliery Guardian, vol. 123, no. 3206, June 9, 1922, pp. 1420–1421, 4 figs. New type which effects operation of opening and closing inlet and outlet ports by means of alternate axially reciprocating and rotary-oscillating movements of piston or cylinder itself.

PUMPS, CENTRIFUGAL

Efficiency. Centrifugal Pumps—Notes on Efficiency, E. T. Keenan. Southern Engr., vol. 37, no. 4, June 1922, pp. 39–40, 2 figs. Factors bearing on efficiency of turbine and volute pumps.

Electrically Driven. Centrifugal Pumps and Pipe Lines (Om Centrifugalpumper og Rörledninger), Rich. Holm. Ingeniören, vol. 31, no. 29, May 20, 1922, pp. 181–185, 10 figs. Discusses electrically driven pumps, power required, effective working, friction, etc.

Submersible Motor. Submersible Motors. Practical Engr., vol. 65, no. 1842, June 15, 1922, pp. 371–372, 2 figs. Extreme portability, lightness and compactness; suction lift of 30 ft.; when pump is working submerged no suction hose or priming is required; advantages of this device.

R

RADIATORS

Casting Parts. Carting of Radiator and Boiler Parts (Fortschritte in der Radiatoren- und Gliederkessel-Giesserei), Carl Irresberger. Giesserie-Zeitung, vol. 19, nos. 12 and 13, Mar. 21 and 28, 1922, pp. 185–189 and 204–205, 14 figs. Mar. 21: Operations connected with casting of radiators. Mar. 28: Patterns, forms and casting of boiler parts.

RAILWAY CONSTRUCTION

Leipzig, Germany. The Rearrangement of the Leipzig Railway Facilities (Die Umgestaltung der Leipziger Bahnanlagen durch die Preussische und Sächsische Staatseisenbahnverwaltung), H. Rothe, H. Mirus, H. Christoph, H. Schmitz and H. Schlunk. Zeit. für Bauwesen, vol. 71, nos. 4–6, 7–9, 1921, pp. 168–198, 259–299 and vol. 72, nos. 1–3 and 4–6, 1922, pp. 37–76 and 134–156, 267 figs. partly on supp. plates. General notes on plan of entire railway installation in and around Leipzig; union passenger and freight stations, including description of plan of lines; interlocking machines; light and power supply, water supply and drainage installations; passage of city streets through terminal zone, including laying of new street and construction of iron viaduct.

RAILWAY ELECTRIFICATION

Austria. The Work of Electrification of the Austrian State Railways at the Beginning of 1922 (Der Stand der Arbeiten in die Elektrisierung der österreichischen Bundesbahnen zu Beginn des Jahres 1922), Paul Dittes. Elektrotechnik u. Maschinenbau, Special Number June 1922, pp. 1–34, 57 figs. Canal construction work in progress at Lake Spüller; extension of Rutz works; turbine equipment and electric

installation of both works; details of transmission masts and transmission lines; current feeds of locomotives; etc. See also Zeit. des Österr. Ingenieur-u. Architekten-Vereines, vol. 74, no. 23-24, June 9, 1922, pp. 99-106, 4 figs.

Chilean State Railways. Electrification of the Chilean State Railways. Engineer, vol. 133, no. 3470, June 30, 1922, pp. 711-714, 11 figs. Utilization of great water power resources for reducing working expenses, increasing traffic capacity and obviating dependence on coal supply from other countries; technical features of problem.

English Main Line. The Electrification of English Main Line Railways, Henry Fowler. Instn. Mech. Engrs. Proc., no. 2, 1922, pp. 317-330. Discussion of paper presented at joint meeting of Instn. Mech. Engrs., Instn. Civil Engrs., and Instn. Elec. Engrs.

Japan. Electrification of the Chichibu Railway of Japan, C. A. Bereaw. Ry. Rev., vol. 70, no. 24, June 17, 1922, pp. 911-912, 2 figs. Five 41-ton locomotives shipped by Westinghouse Co., represent first shipment of electric locomotives from America for operation on steam-railroad electrification in Japan.

Switzerland. Conclusion of the Work of Electrification of Rhaetian Railway (Der Abschluss der Elektrifizierungsarbeiten der Rhätischen Bahn) W. Durler. Schweizerische Bauzeitung, vol. 79, nos. 14, 15, 20, 21 and 22, Apr. 8, 15, May 20, 27 and June 3, 1922, pp. 180-183, 194-198, 249-254, 267-269 and 279-281, 26 figs. Apr. 8 and 15: Discusses power plants at Thusis and Kublis, and their equipment, transmission lines, distributing system, transformers, etc. May 20: Describes the various types of electric locomotive and gives particulars as to their wiring and connecting. May 27: Data of trial runs of locomotives, and heating of trains. June 3: Discusses workshops and enginehouses and their equipment.

RAILWAY MOTOR CARS

Advantages of. What is the Future for Automotive Rail Cars? L. G. Plant. Ry. Rev., vol. 70, no. 24, June 17, 1922, pp. 930-934, 3 figs. Modern features which are recommended for light local passenger service. From paper read before Soc. Automotive Engrs.

Diesel-Electric. Diesel-Electric Motor Cars for Railway Service. Ry. Mech. Engr., vol. 96, no. 6, June 1922, pp. 314-315, 2 figs. Successful operation in Sweden has led to introduction of 250-hp. cars.

Gasoline. Some Recent Developments in Gasoline Passenger Rail Cars, W. L. Bean. N. Y. R. R. Club Proc., vol. 32, no. 7, May 19, 1922, pp. 6713-6726 and (discussion) 6726-6744, 6 figs. Considerations which may assist in reducing charges by substituting for light steam trains.

Developments in Gasoline Passenger Rail Cars, W. L. Bean. Ry. Age, vol. 73, no. 1, July 1, 1922, pp. 17-20 (includes discussion), 3 figs. Design, power requirements and operating results of self-propelled cars. (Abstract.) Paper read before N. Y. R. R. Club.

120 Hp. Gasoline Motor Features New Rail Car Design. Ry. Rev., vol. 70, no. 24, June 17, 1922, pp. 934-937, 8 figs. Low maintenance and adaptability to wide range of rail requirements objective in latest automotive development.

New Features. New Features in Service Railway Motor Coach. Ry. Mech. Engr., vol. 96, no. 6, June 1922, pp. 337-338, 3 figs. Unique type of truck with cushioned wheels; high seating capacity combined with light weight.

Pittsburgh and Shawmut. Operation of Motor Cars on the Pittsburgh & Shawmut, D. C. Morgan. Ry. Rev., vol. 70, no. 24, June 17, 1922, pp. 928-929, 3 figs. Costs less to operate than local steam train; affords better and more frequent service. Paper read before N. Y. R. R. Club.

RAILWAY OPERATION

Train Control. Schweyer Automatic Train Control. Ry. Elec. Engr., vol. 13, no. 6, June 1922, pp. 187-189, 3 figs. Intermittent, non-contact, inert roadside element type.

The Sprague Train Control System. Ry. Signal Engr., vol. 15, no. 6, June 1922, pp. 226-230, 9 figs. Description of display system of auxiliary control by magnets.

RAILWAY REPAIR SHOPS

Albuquerque, N. M. A. T. & S. F. Ry. Shop Improvements at Albuquerque. Ry. Rev., vol. 70, no. 24, June 17, 1922, pp. 889-896, 16 figs. Engineering and mechanical features of improvement program of largest locomotive erecting shop in West, involving expenditure of about $10,000,000.

Car Equipment Scheduling. Scheduling of Car Equipment Through Repair Shops. Ry. Rev., vol. 70, no. 25, June 24, 1922, pp. 965-970, 6 figs. Am. Ry. Assn. Committee urges scheduling of heavy freight and passenger car repairs on same principle as recommended for locomotive repairs in 1922 report.

Glass Walls in. Santa Fe Ry. Has Large Steel-Frame Shop with Glass Walls. Eng. News-Rec., vol. 89, no. 1, July 6, 1922, pp. 12-15, 9 figs. Glazing outside structural framing; T-columns carry 250-ton crane; folding rack doors; repair pits and floor track construction.

Grinding Practice. Railway Shop Grinding Practice in England. Ry. Mech. Engr., vol. 96, no. 6, June 1922, pp. 325-327, 3 figs. Interesting machines developed for grinding locomotive cylinders, car journals and mounted crank-pins.

Locomotive. Modern Management of Locomotive Boiler Repair (Neuzeitliche Betriebsführung in der Lokomotivekessel-Ausbesserung). Glasers Annalen, vol. 90, nos. 10 and 11, May 15 and June 1, 1922, pp. 169-181 and 200-205 and (discussion) 205-207, 36 figs. May 15: Management of staybolts and rivets, and operations connected with them. June 1: Record keeping of boiler repairs, and their management.

Passenger-Car. The Design of Passenger Car Repair Shops. Ry. Mech. Engr., vol. 96, no. 6, June 1922, pp. 332-336, 1 fig. Requirements for various departments outlined and typical layouts proposed by A.R.E.A. Committee.

Power Plants. Some Factors in the Design of Railway Power Plants. Ry. Rev., vol. 70, no. 25, June 24, 1922, pp. 991-995, 5 figs. Am. Ry. Assn. Committee on modernization of stationary boiler plants advocates welding pipe lines and reports on relative merits of steam turbines and uniflow engines. (Abstract.)

RAILWAY SIGNALING

Automatic. New Signaling on the Big Four, C. F. Stoltz. Ry. Signal Engr., vol. 15, no. 6, June 1922, pp. 221-224, 6 figs. A. C. floating battery installed for operation of 68 miles of double track automatics shows economy in operation.

Automatic Block. Automatic Block System in Operation at the Grande Ceinture (Block-System automatique en service sur la Grande Ceinture), Bernard. Révue Générale des Chemins de Fer et des Tramways, vol. 41, no. 6, June 1922, pp. 457-467, 10 figs. Describes Lartigue signaling system in use in Paris, its construction and operation, which so far has worked satisfactorily.

Operation, Economy in. Introducing Economies in Signal Operation, Sidney L. Baxter. Ry. Signal Engr., vol. 15, no. 6, June 1922, pp. 231-232, 4 figs. Storage batteries replaced by primary battery, electric lights installed, and maintenance force reduced.

Wires and Cables. Railroad Signal Wires and Cables, Wm. A. Del Mar and F. A. Westbrook. Ry. Signal Engr., vol. 15, no. 6, June 1922, pp. 233-239, 15 figs. Methods of installation and causes of deterioration of rubber insulated conductors.

RAILWAY STATIONS

Waterloo, England. The New Waterloo Station, London & South Western Railway. Ry. Gaz., vol. 36, no. 23, June 9, 1922, pp. 919-936, 25 figs. Description of rebuilding of largest station in British Isles and facilities provided.

RAILWAY TERMINALS

Mississippi River-and-Rail. New River-and-Rail Terminals on the Mississippi. Eng. News-Rec., vol. 89, no. 1, July 6, 1922, pp. 18-20, 3 figs. Truck conveyor bridge and car incline with cradle provide for varying river level; two concrete docks with cranes.

Detroit. Pennsylvania to Complete Entrance into Detroit. Ry. Age, vol. 72, no. 25, June 24, 1922, pp. 1717-1718, 1 fig. Project includes local freight terminal, classification yard and 25 miles of new line.

RAILWAY TRACK

Elevation. Aurora Track Elevation Expedites Traffic. Ry. Age, vol. 73, no. 1, July 1, 1922, pp. 7-11, 8 figs. Burlington's grade separation project is supplemented by plan for increasing facilities.

RAILWAY YARDS

Freight. New Haven Builds Freight Yards at Providence. Ry. Age, vol. 72, no. 24, June 17, 1922, pp. 1467-1470, 4 figs. New terminal forms important unit in broad improvement program to effect operating economies.

REFRIGERATING MACHINES

Condensers, Free-Air. Influencing the Pressure of Free-Air Condensers, M. Hirsch. Ice & Refrigeration, vol. 62, no. 6, June 1922, pp. 457-459, 4 figs. Descriptive article with charts on subject; formula for measuring difference of vapor tension between water surface and moisture contained in surrounding atmosphere; empirical curves for regulation of water and air.

REFRIGERATING PLANTS

Ice-Cream. Modern Ice-Cream Plant, Frank D. Chase. Ice & Refrigeration, vol. 62, no. 6, June 1922, pp. 454-456, 5 figs. Diagrams and description of modern ice-cream plant; factors to be considered; taking advantage of law of gravity; anticipation of provision for future; sanitation; ventilation and welfare requirements.

Overhauling. Overhauling the Refrigerating Plant, J. J. Grover. Southern Engr., vol. 37, no. 4, June 1922, pp. 46-49, 4 figs. Pointers regarding what to do when getting ready for season's run.

REFRIGERATION

Absorption Process. Refrigeration for the Power Plant Engineer. Power House, vol. 15, no. 12, June 20, 1922, pp. 31-32, 34, 2 figs. Absorption process of refrigerating; aqua ammonia; general construction and details of parts of machine; few words on operating features.

Absorption System. Outline of the Absorption Refrigerating System, D. L. Fagnan. Power, vol. 55, no. 25, June 20, 1922, pp. 977-979, 2 figs. Discussion of functions of several parts; cycle of events in system; operating procedure to be followed.

RELATIVITY

Theory. Criticism of the Theories of Relativity (Critiques des théories de la rélativité), P. Juppont. Génie Civil, vol. 80, nos. 19, 20 and 21, May 13, 20 and 27, 1922, pp. 430-431, 443-446 and 468-473, 2 figs. May 13: Discusses relativity and postulates, force, action and reaction, temperature, entropy. May 20: Relativists' solutions of these problems; inadequacy of relativity; Lorentz contractions. May 27: Shows that Einstein's theory is not a physical theory. Physical mechanics; mechanical force and power.

RESEARCH

Malleable Iron. Malleable Castings Research Laboratory. Iron Age, vol. 109, no. 26, June 29, 1922, pp. 1819-1820, 2 figs. Freedom from routine tests permits concentration on work to advance state of art.

ROLLING MILLS

Efficiency. Effective Work of the Rolling Mill (Die Nutzarbeit des Walzvorgangs), G. Liss. Stahl u. Eisen, vol. 42, nos. 18, 19, 20, 21 and 23, May 4, 11, 18, 25 and June 8, 1922, pp. 689-697, 735-741, 768-772, 806-816 and 891-896, 24 figs. May 4 and 11: Discusses deformation generally; velocity of changing forms per second per unit of volume in various rolling processes; power factor depending on temperature and velocity; etc. May 18: The external mechanical process during rolling, spreading and elongation, shaping, pressure and friction of rolls. May 25: Discusses resistance to deformation as dependent upon block temperature. June 8: Effect of velocity of changing form; determination and comparison of effective work.

Electrically Driven. Steel Rolled for Less on Electric Mills than with Steam Drive, G. E. Stoltz. Elec. World, vol. 80, no. 1, July 1, 1922, pp. 7-10, 2 figs. Records show that steam mills can often be replaced by electric mills with marked advantages; accurate cost accounting is possible with electric mills, and labor and maintenance costs are reduced.

Ship-Plate. The Dominion Iron and Steel Company's New Ship-Plate Rolling Mill, H. E. Rice. Can. Min. Inst. Trans., vol. 23, 1920, pp. 167-178, 5 figs. Description of $5,000,000-installation with its Lauth type 110-in. by 36-in. three-high plate mill driven by 4,000-hp. 82 r.p.m. special motor.

S

SAFETY

Electric Power Stations. Safety as Applied to Operating Equipment of Large Electric Power Station, E. W. Gorry. Safety Eng., vol. 43, no. 6, June 1922, pp. 261-268. Provisions at plants and sub-stations of United Elec. Light & Power Co. and new Edison Company. Paper read before A.S.S.E.

Safety is Built into the Design of the New Hell Gate Electric Power Station, E. M. Van Norden. Safety Eng., vol. 43, no. 6, June 1922, pp. 257-260. Precautions resulting from knowledge of conditions existing at other stations where trouble has been experienced. Paper read before A.S.S.E.

SAND BLAST

Apparatus. Development of Sand Blast Apparatus in Germany and America (Die Entwicklung des Sandstrahlgebläsebaues in Deutschland und Amerika), W. Kaempfer. Giesserei-Zeitung, vol. 19, no. 19, May 9, 1922, pp. 289-292, 15 figs. Discusses the various types of apparatus and their operation.

SAND, MOLDING

Properties for Steel. Study Properties of Steel Sand. Iron Trade Rev., vol. 71, no. 2, July 13, 1922, pp. 103-106, 8 figs. Facing mixtures must possess highly refractory qualities to resist intense heat of steel at pouring temperatures; determining standards for measuring permeability and strength.

SCRAP

Railway, Reclamation of. Scrap Reclamation on the Chesapeake and Ohio. E. A. Murray. Ry. Mech. Engr., vol. 96, no. 6, June 1922, pp. 308-311, 8 figs. Methods used and savings effected in reclaiming locomotive, car and other parts at Huntington shops.

SEPARATORS

Magnetic. New Magnetic Separator for Low Magnetic Ores (Neue Magnetscheider für schwachmagnetische Erze), H. Bernhardt. Technische Blätte vol. 12, no. 10, Mar. 11, 1922, pp. 105-106, 4 figs. Discusses drum separators for large and small size of grain, and describes their operation.

SHIP PROPULSION, ELECTRIC

Machinery on SS San Benito. The Electric Propelling Machinery of the "San Benito." Engineering, vol. 113, no. 2946, June 16, 1922, pp. 749-752, 13 figs. Developing 2,500 s.hp. with propeller speed of 100 r.p.m. Turbo-alternator rated at 2,040 kw. at 3000 r.p.m. has 9-stage turbine operating on 190 lb. steam with 200 deg. fahr. superheat.

SHIPS

Conversion to Oil-Burning. Cunarder "Berengaria" Converted to Oil-Fuel Burning. Mar. Engr. & Naval Architect, vol. 45, no. 537, June 1922, pp. 236-240, 18 figs. Work of conversion by W. G. Armstrong, Whitworth & Co. Ltd., Walker-on-Tyne; White low-pressure oil-burning system by White Patent Oil Fuel Co.; largest boiler repair contract ever carried out on Tyne; general reconditioning and overhaul.

Gyrostabilizer. The Latest Sperry Gyro-Stabilizer Installation. Mar. Engr. & Naval Architect, vol. 45, no. 537, June 1922, pp. 218-219, 2 figs. New 120-ton stabilizer to be installed on American passenger liner "Hawkeye State;" general principles; some particulars of rolling experiments recently carried out on Italian destroyer.

SHOVELS

Rotary. The Clere Mechanical Rotary Shovel (Pelle mécanique rotative, système Clere), E. Weiss.

Génie Civil, vol. 80, no. 21, May 27, 1922, pp. 477–479, 8 figs. Describes Clere system for mechanical excavating, loading, etc.

SPRINGS

Accidents to, Securing Against. Securing Springs Against Accident. Autocar, vol. 48, no. 1389, June 3, 1922, pp. 939–940, 2 figs. Description of some of devices employed to prevent fractured spring leaf from entirely deranging steering.

Laminated, for Automobiles. Laminated Springs for Automobiles, T. H. Sanders. Machy. (Lond.), vol. 20, nos. 501, 503, 505, 507 and 508, May 4, 18, June 1, 15 and 22, 1922, pp. 125–128, 185–188, 249–253, 317–321 and 345–348, 28 figs. Discussion of design of modern manufacturing appliances and processes and effect of standardization on production.

STEAM

Consumption. Steam and Steam Consumption (Wasserdampf und Dampfverbrauch), A. Hinz. Gluckauf, vol. 58, no. 24, June 17, 1922, pp. 705–739, 18 figs. partly on supp. plate. Discusses structure of is-diagram (heat content and entropy) for steam, and Mollier table, and shows possibility of their application in number of examples for determination of theoretical consumption of steam per unit of performance.

Production and Use. Economies in Steam-Raising, T. W. Harper. Gas Jl., vol. 158, no. 3075, Apr. 19, 1922, pp. 154–156. Lancashire versus water-tube boilers; boiler settings and flues; feedwater and scale; fuel and grate; waste-heat utilization; superheaters; steam distribution. Paper read before North British Assn. Gas Managers.

Production and Utilization. Commission for the Utilization of Fuels—5th Report (Commission d'Utilization du Combustible—Cinquième Rapport), V. Krammerer. Annales des Mines, vol. 1, no. 5, May 1922, pp. 348–394. Production and utilization of steam; transportation of steam; steam power and pressure; application of steam in industries.

Work of the Fuel Utilization Commission, V. Kammerer. (Travaux de la Commission d'Utilisation du Combustible.) Bul. de la Société d'Encouragement pour l'Industrie Nationale, vol. 134, no. 1, Jan. 1922, pp. 50–78. Report on production and utilization of steam, including transmission, motive power, use of steam for manufacturing and heating purposes, etc. See also Chaleur et Industrie, no. 24, Apr. 1922, pp. 1175–1182.

Supersaturated Condition. The Supersaturated Condition as Shown by Nozzle Flow, Prof. A. L. Mellanby. Engineering, vol. 113, no. 2948, June 30, 1922, pp. 832–835, 11 figs. Investigation of flow quantities exceeding those calculated on assumption of isentropic expansion of saturated steam. Paper read before Inst. Mech. Engrs.

STEAM ACCUMULATORS

Ruths. The Ruths Steam Accumulator on the Basis of the Patents of the Vaporackumulator Company in Stockholm (Der Ruths-Dampfspeicher auf Grund der Patente der Aktiebolaget Vaporackumulator in Stockholm). Kali, vol. 16, no. 12, June 15, 1922, pp. 234–238, 1 fig. Advantages of principle of steam accumulation for regulation of steam pressure; claims as stated in 17 German patents.

STEAM ENGINES

Uniflow. The Uniflow Steam Engine Industry. Power, vol. 55, no. 25, June 20, 1922, pp. 960–964, 8 figs. Characteristics of this high-efficiency type which is thought to have kept steam-engine development from stagnation.

Uniflow Lubrication. Lubricating the Uniflow Engine. Practical Engr., vol. 65, no. 1841, June 8, 1922, pp. 363–364. Errors in common practice indicated relieving excessive compression; selection of oil; speed and friction.

STEAM POWER PLANTS

Amsterdam. New Steam Plant at Amsterdam. Power Plant Eng., vol. 26, no. 13, July 1, 1922, pp. 639–645, 10 figs. Description of steam-turbine plant with an ultimate capacity of 200,000 hp.; boiler room; electric generating equipment; control equipment.

STEAM TRAPS

Selection and Use. Steam Traps—Their Selection, Installation and Upkeep, E. Smiley. Power, vol. 56, no. 2, July 11, 1922, pp. 45–48. General consideration and method of distinguishing actual leakage of steam from vapor formed by re-evaporation.

STEAM TURBINES

Exhaust Type. The Exhaust Steam Turbine, W. R. Woolrich. Nat. Engr., vol. 26, no. 6, June 1922, pp. 250–252, 3 figs. Why this type has proven economical in conjunction with steam engine; vacuum as factor in economy; performance data.

Flow Phenomena and Design. Flow Phenomena and the Design of Large Steam Turbines (Strömungsvorgänge und Aufbau grosser Dampfturbinen), G. Zerkowitz. Zeit. des Vereines deutscher Ingenieure, vol. 66, nos. 22 and 23, June 3 and 10, 1922, pp. 533–536, 561–565, 15 figs. June 3: Incomplete expansion; means for reducing wear of turbine parts. June 10: Limits of efficiency; effect of great lengths of blades on flow of steam; etc.

STEEL

Arc-Deposited. Properties of Arc Deposited Steel, O. H. Eschholz. Iron Age, vol. 109, no. 26, June 29, 1922, pp. 1803–1805, 7 figs. Cast and hammer forged metal under static and dynamic stress as produced by direct current and steel electrodes.

Electrolytic Building Up. A Successful "Putting On" Tool for Steel Parts, David R. Kellogg. Elec. Jl., vol. 19, no. 6, June 1922, pp. 249–251. Satisfactory method for depositing metal where it has been removed by wear or inaccurate workmanship.

Fatigue. Fatigue in Annealed and Tempered Carbon Steels (Über die Ermüdung geglühter und vergüteter Kohlenstoffstähle), W. Müller and H. Leber. Zeit. des Vereines deutscher Ingenieure, vol. 66, no. 22, June 3, 1922, pp. 543–546, 8 figs. Experiments with steels of various carbon content; relation between fatigue and tempering and mechanical properties of steel.

Identification by Spark. Steels and Their Sparks Metal Industry (Lond.), vol. 20, no. 23, June 9, 1922, pp. 549, 551–552, 10 figs. Determining character of steel by examination of sparks given off when sample is held against abrasive wheel.

Stainless. Stainless Steels and the Making of Cutlery R. G. Hall. Am. Soc. for Steel Treating Trans. vol. 2, no. 7, Apr. 1922, pp. 561–565 and (discussion) 566–568, 6 figs. Manufacture of stainless steel blade, while not materially different in shape or size from that of ordinary carbon-steel blade, is shown to be a great deal more costly.

STEEL CASTINGS

Foundry For. Makes Valves in New Foundry, H. R. Simonds. Foundry, vol. 50, no. 11, June 1, 1922, pp. 431–435, 13 figs. Description of steel foundry built by Chapman Valve Co. for manufacture of steel castings.

Manufacture. The Production of Light Steel Castings, H. Spencer Kipling. Metal Industry, vol. 20, no. 21 and 22, May 26 and June 2, 1922, pp. 493, 495 and 525–526. Suggestions for overcoming metal difficulties of making castings for this type.

STEEL, HEAT TREATMENT OF

Carbon- and Chromium-Molybdenum Steel. Effect of Heat Treatment on Mechanical Properties of a Carbon-Molybdenum and A Chromium-Molybdenum Steel, H. J. French. Am. Soc. for Steel Treating Trans., vol. 2, no. 9, June 1922, pp. 769–797 and (discussion) 797–798, 17 figs. Summary of results of previous tests and comparison of treatments for production of high resistance to impact and best combination to strengthen ductility.

Cooling and Heating. The Proper Heating and Cooling of Steel, John A. Succop. Can. Machy., vol. 27, no. 22, June 1, 1922, pp. 42–44, 4 figs. Less trouble experienced with small masses; all portions of piece should be subjected to same temperature; human element weakest link; temperature and time most important factors. Paper read before Am. Soc. for Steel Treating.

Annealing Overstrained Steel. The Efficiency of Annealing Overstrained Steel, I. H. Cowdrey. Am. Soc. for Steel Treating Trans., vol. 2, no. 9, June 1922, pp. 802–808, 3 figs. Tests made to determine extent to which treatment of overstrained steel is successful.

Magnetic Properties, Influence on. The Influence of Heat Treatment Upon the Magnetic Properties of Steel, Lancelot W. Wild. Am. Soc. for Steel Treating Trans., vol. 2, no. 8, May 1922, pp. 696–704, 6 figs. Intensity of magnetization, permeability, residual induction, and coercive force. Bibliography.

STEEL, HIGH-SPEED

Tests, Physical. Physical Tests on High-Speed Steels, A. H. D'Arcambal. Iron Age, vol. 110, no. 1, July 6, 1922, pp. 1–5, 7 figs. Transverse and tensile tests of two grades compared; effect of these properties on service of tool.

STEEL MANUFACTURE

Direct Process. A Direct Method of Steel Manufacture, A. E. Bourcoud. Iron Age, vol. 109, no. 20, May 18, 1922, pp. 1349–1351, 3 figs. Discussion of Bourcoud process and possibility of using oil, lignites and other fuels; data on costs. (Abstract.) Paper presented at meeting of Am. Iron and Steel Inst.

Tropenas Converter. Tropenas Converter for Making Steel, S. R. Robinson. Blast Furnace & Steel Plant, vol. 10, no. 5, May 1922, pp. 282–284. General description of this process, details of converter and information regarding cupola change. This process is very similar to the bessemer process.

STEEL WORKS

Electrification. The General Effect of Electrification on the Operation of Steel Mills, W. Sykes. Blast Furnace & Steel Plant, vol. 10, no. 6, June 1, 1922, pp. 306–312. Some interesting figures on operation of mills at Mark Plant are included; writer believes electric power is more economical than steam power.

Calumet Steel Company Electrify Mills, L. H. Hook and F. R. Burt. Blast Furnace & Steel Plant, vol. 10, no. 6, June 1, 1922, pp. 313–316, 4 figs. Rotary converter adjustable speed sets as applied to rail rerolling mill; twelve stands of rolls are now electrically driven.

France. The Hagondange Works [Les Usines d'Hagondange (Moselle)], J. Siegle. Révue de Métallurgie, vol. 19, no. 6, June 1922, pp. 313–351, 27 figs. Describes iron works of Union des Consommateurs de Produits metallurgiques et industriels; mines operated by company; blast furnaces worked, their operation; steam production and use; compressed air; electric current; Thomas converters; rolling mills; workmen's dwellings.

France. The Unieux Foundry and Steel Works (Les Forges et Aciéries d'Unieux). Outillage, Tome 260, no. 20, May 20, 1922, pp. 652–655, 13 figs. partly on supp. plate. Describes works established by Jacob Holtzer, situated in Ondaine Valley, near Firminy, France, and its equipment.

STOKERS

Chain-Grate. A New Chain-Grate Stoker. Mar. Engr. & Naval Architect, vol. 45, no. 537, June 1922, pp. 246–247, 1 fig. Mechanical method of coal firing; self-cleaning features; application of chain-grate to marine boilers.

Selection. What to Know When Selecting Stoker Equipment, J. G. Worker. Power, vol. 55, no. 17, Apr. 25, 1922, pp. 647–650. Combustion characteristics of principal coals; types of stokers best suited to burn them.

STORAGE BATTERIES

Lead Hydrate. Some Reflections on the Lead Hydrate Accumulator, W. R. Cooper. Electrician, vol. 88, no. 2298, June 2, 1922, pp. 654–656, 1 fig. Examination of claims made for new type and consideration of characteristics.

STREET RAILWAYS

Toronto's Rolling Stock. Toronto's Progressive Rolling Stock. Elec. Ry. Jl., vol. 59, no. 21, May 27, 1922, pp. 867–870, 10 figs. Toronto Transportation Commission has added 250 new cars to its passenger rolling stock and has remodeled more than 350 other cars.

Turnstile Cars. Improvement in Turnstile Cars. Elec. Ry. Jl., vol. 59, no. 19, May 13, 1922, pp. 787–789, 6 figs. One-man operation with double-truck cars in Utica and Syracuse has increased steadily until now Utica has 100 per cent operation. Improvements in turnstile arrangement are described.

STRESSES

Allowable, Safety and. Factors of Safety and Allowable Stress, C. D. Albert. Am. Mach., vol. 57, no. 2, July 13, 1922, pp. 54–57. Meaning of allowable stress; factors of safety for live and dead loads; effects of fatigue, shock, and uncertainty as to actual conditions existing.

Torsional. Torsional Stresses (Die Lehre der Drehungsfestigkeit), Constantin Weber. Forschungsarbeiten auf dem Gebiete des Ingenieurwesens, no. 249, 1921, 70 pp., 170 figs. Discusses phenomena of torsion, stresses occurring, conditions of equilibrium, internal change of form; develops formulas and makes calculations; application to various cross-sections.

Two-Dimensional. Some Special Cases of Two Dimensional Stress or Strain, C. E. Inglis. Engineering, vol. 113, no. 2945, June 9, 1922, pp. 732–733, 8 figs. Mathematical consideration in six special cases in plates.

SUBWAYS

Safety and Operating Developments, London. "Safety" and "Operating" Developments on the Underground Railways. Ry. Gaz., vol. 36, no. 22, June 2, 1922, pp. 891–894, 6 figs. Arrangements to cut off current from affected section in 20 to 25 seconds; controller governed by brake system; other features.

T

TAR

Preparation and Uses. Preparation and Uses of Tar and Its Simple Crude Derivatives, W. W. Odell. Bur. of Mines, Dept. of Interior, Technical Paper 268, 1922, 84 pp., 13 figs. General treatise on utilization of tar and usual methods of working up tar into some of its simple or easily prepared derivatives.

TANKS

Steel, Manufacture of. Role of Steel Tanks is Important, J. D. Knox. Iron Trade Rev., vol. 70, no. 25, June 22, 1922, pp. 1795–1797 and 1806, 3 figs. Manufacturing methods are relieved of details by standardizing product; fabrication involves 24 distinct operations; how large oil tanks are erected; instructions for tank installation.

TELESTEREOGRAPHY

Belin System. Telegraphic Transmission of Photographs. Nature, vol. 109, no. 2743, May 27, 1922, pp. 687–688, 1 fig. Latest developments in which good results have been obtained by French wireless station near Bordeaux and naval station in United States.

TESTS AND TESTING

American Society. American Society for Testing Materials. Iron Age, vol. 110, no. 1, July 6, 1922, pp. 13–18. Annual convention discusses steel castings and pig and cast iron; sulphur in steel; symposiums on impact testing and fatigue of metals.

TEXTILE INDUSTRY

British and American Practice. British and American Textile Manufacturing Practice, Wm. D. Hartshorne. Engrs. & Eng., May 1922, pp. 143–148, 6 figs. Characteristic qualities of wool fiber; comparison of its treatment and results of differences.

TIDAL POWER

Utilization. Utilizing the Power of the Tides and the Motion of the Sea Waves (Utilizzazione della forza delle maree e dell'urto delle onde del mare). Elettricista, vol. 1, no. 10, May 15, 1922, pp. 73–74, 2 figs. Various schemes for generating power; describes plant at Rennes, in France.

TIMBER

Creosoted, Fire Hazard. Are Many Creosoted Timber Structures Destroyed by Fire? Ry. Maintenance Engr., vol. 18, no. 5, May 1922, pp. 167–169. Facts which show that advantages derived from preservative treatment far outweigh any possible hazzards from that source.

TIRES, RUBBER

Damaged, Inspection of. The Inspection o

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